RM-14SA

RADIATION MONITOR TECHNICAL MANUAL

SALES

Eberline A subsidiary of
Thermo Instrument
Systems Inc.

Price List

Repair
Calibration

EFFECTIVE January 1, 1992
Prices are F.O.B. Santa Fe, New Mexico
Subject to change without notice
Terms: ¾ of 1% 10, net 30 days
Minimum order $40.00

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Eberline *A subsidiary of* ***Thermo Instrument*** *Systems Inc.*

P.O. Box 2108
Santa Fe, New Mexico 87504-2108
(505) 471-3232 TLX: 66-0438 EIC SFE
FAX: (505) 473-9221

GENERAL INFORMATION

Instruments for repair or calibration should be packaged, marked, or otherwise prepared in accordance with good commercial practices and shipped F.O.B. destination freight prepaid to one of the Eberline facilities below.

Repair and Calibration Facilities

Eberline Instrument Corporation
504 Airport Road
Santa Fe, NM 87504-2108
Attn: Western Service Center
(505) 471-3232
1-800-274-4212

Eberline Instrument Corporation
312 Miami Street
West Columbia, SC 29169
Attn: Eastern Service Center
(803) 822-8843
1-800-234-4212

Normal turn-around time for repair (Eberline instruments) is fifteen working days.

Normal turn-around time for calibration (Eberline instruments) is seven working days.

Prices (Subject to change without notice)

Certified calibration (Eberline portable instruments)(2 points/range)	
Unit and one probe	$90.00
Second probe	45.00
Third or fourth probe (Limited to 4 probes per instrument)	25.00
Certified calibration (other manufacturer's portable instruments)	90.00
ALPHA-3, ALPHA-5, AMS-3, HFM's, Portal Monitors, RM-22, SAM-2, WLM-1A, ESP-2 6112B, 6112D (certified calibration)	145.00
RGM-2 (certified calibration)	405.00
RGM-3 (certified calibration)	235.00
As found readings on any of the above, a charge of 50% of calibration rate shall be made.	
Calibrate "non-removeable" contaminated instruments	QUOTE
Services Contracts (Eberline equipment)	QUOTE
Technical Specification writing and Consultation	QUOTE
Service Engineer at Customers Site	$925.00/day plus expenses at cost +10% adm.
-Over 8 hours or Saturday and Sunday	165.00/hr
-Eberline Holidays	220.00/hr
Consulting	1,025.00/day
Repair rate (plus calibration and parts at list price)	85.00/hr
Repair "non-removeable" contaminated instruments	95.00/hr
Expediting Fee	50.00/ instrument
Accredited secondary standards laboratory calibration (Cs^{137} and Co^{60} photon)	QUOTE

Note: Repair and Calibration time on non-Eberline instruments is subject to availability of parts and literature for the specific instrument.

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Eberline warrants to replace or repair, at its option, any repaired products or replaced parts thereof (excluding tubes, crystals, batteries and normal consumables) which are found defective in material or workmanship within ninety (90) days from date of repair or the balance of the new purchase warranty, whichever occurs later. Instruments calibrated by Eberline are warranted to be within specified limits at time of shipment. In the event of calibration error, Eberline will again calibrate the instrument without charge to the instrument owner. The aforesaid warranty does not cover life-end failure of components and will be voided if repair has been attempted by other than seller's authorized personnel. In no event shall Eberline be liable for consequential or special damages, transportation, installation, adjustment, work done by customer or other expenses which may arise in connection with such defective product or parts.

Exclusion of Warranties and Limitation of Liability

The foregoing warranty is expressly made in lieu of any and all other warranties express or implied including the warranties of merchantability and fitness for a particular purpose. Under no circumstances shall seller be liable for any indirect, special, incidental, or consequential damages to customer or to any third party.

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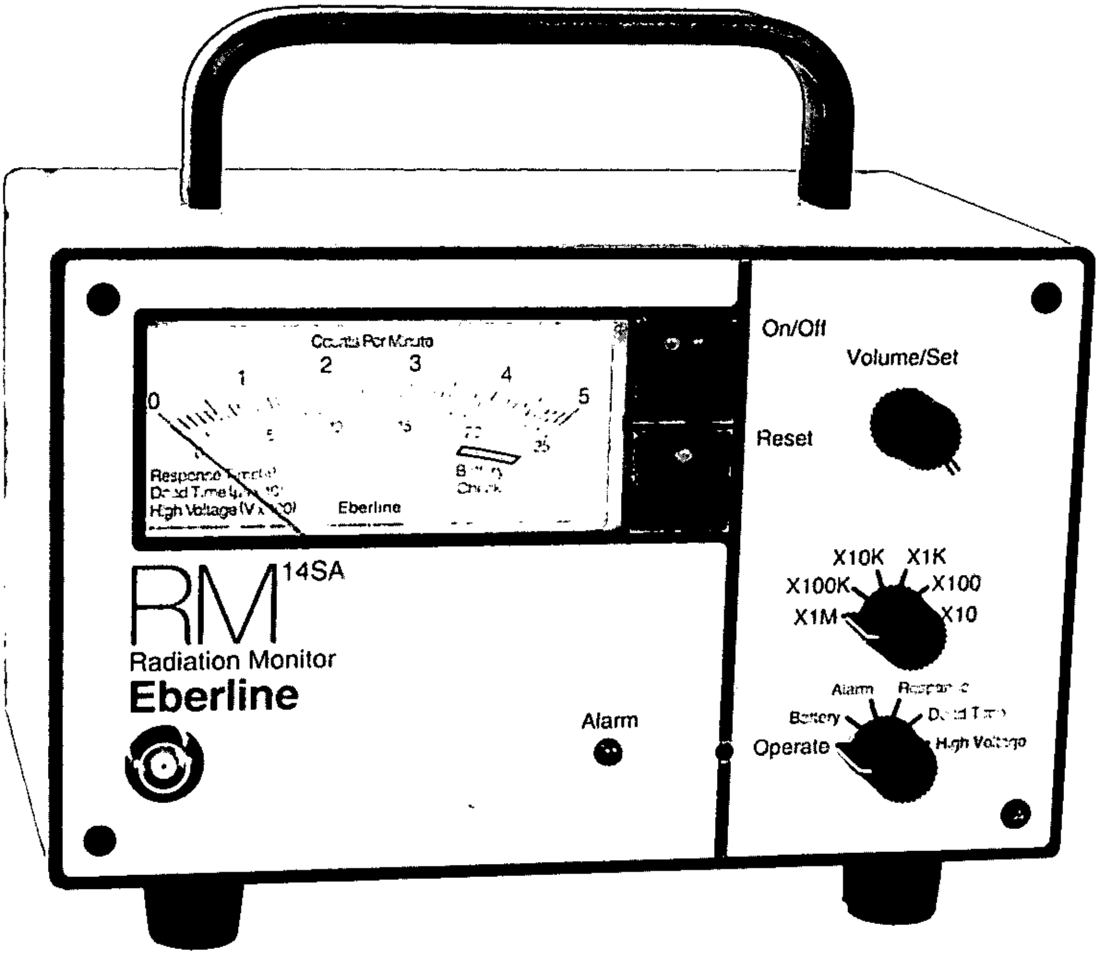
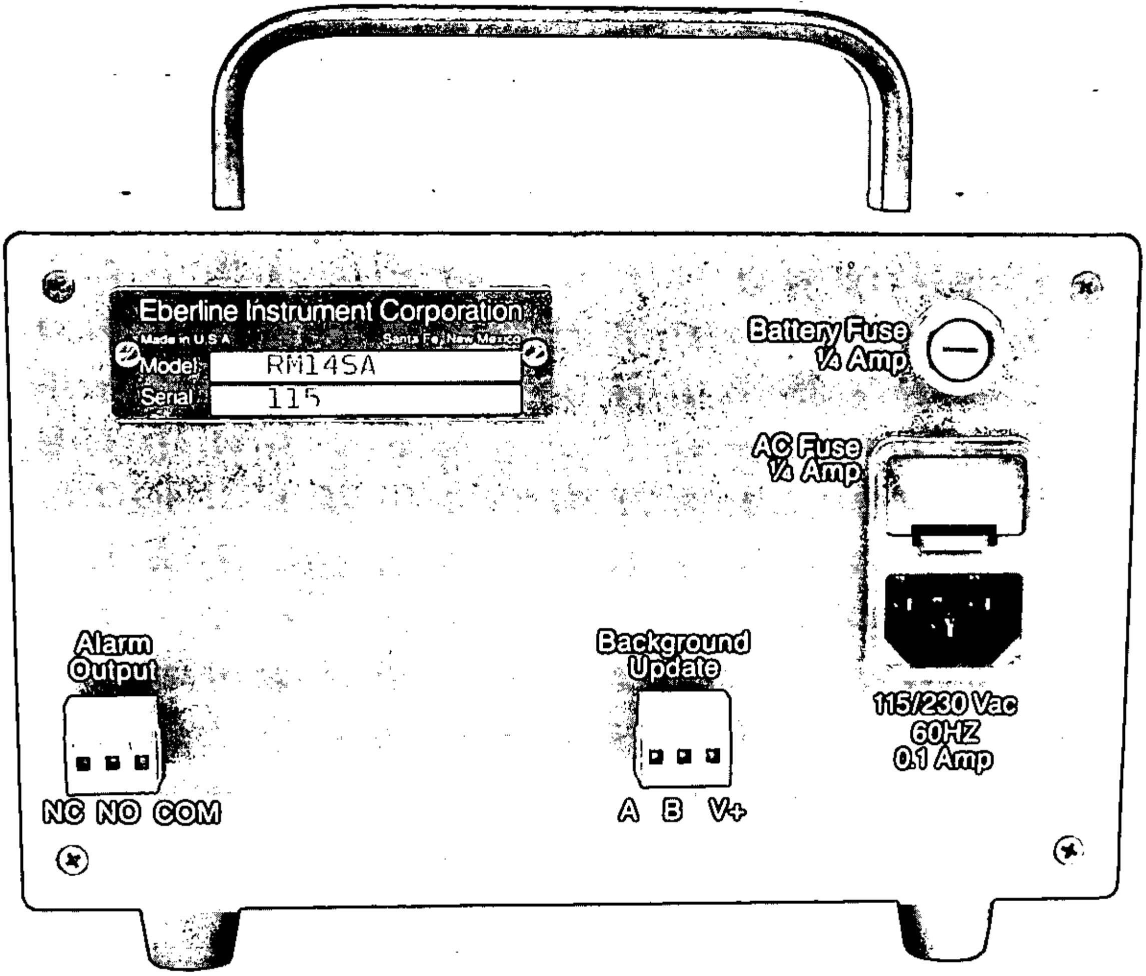
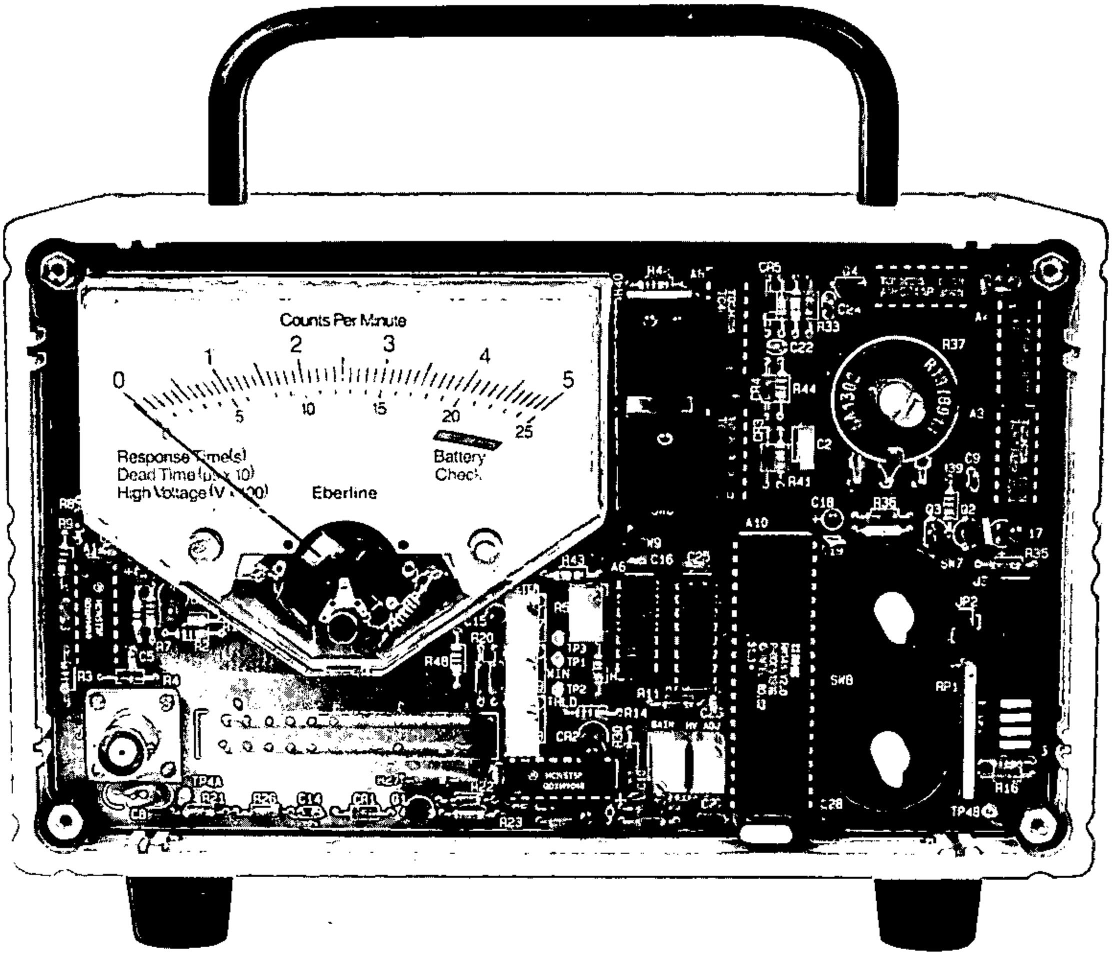


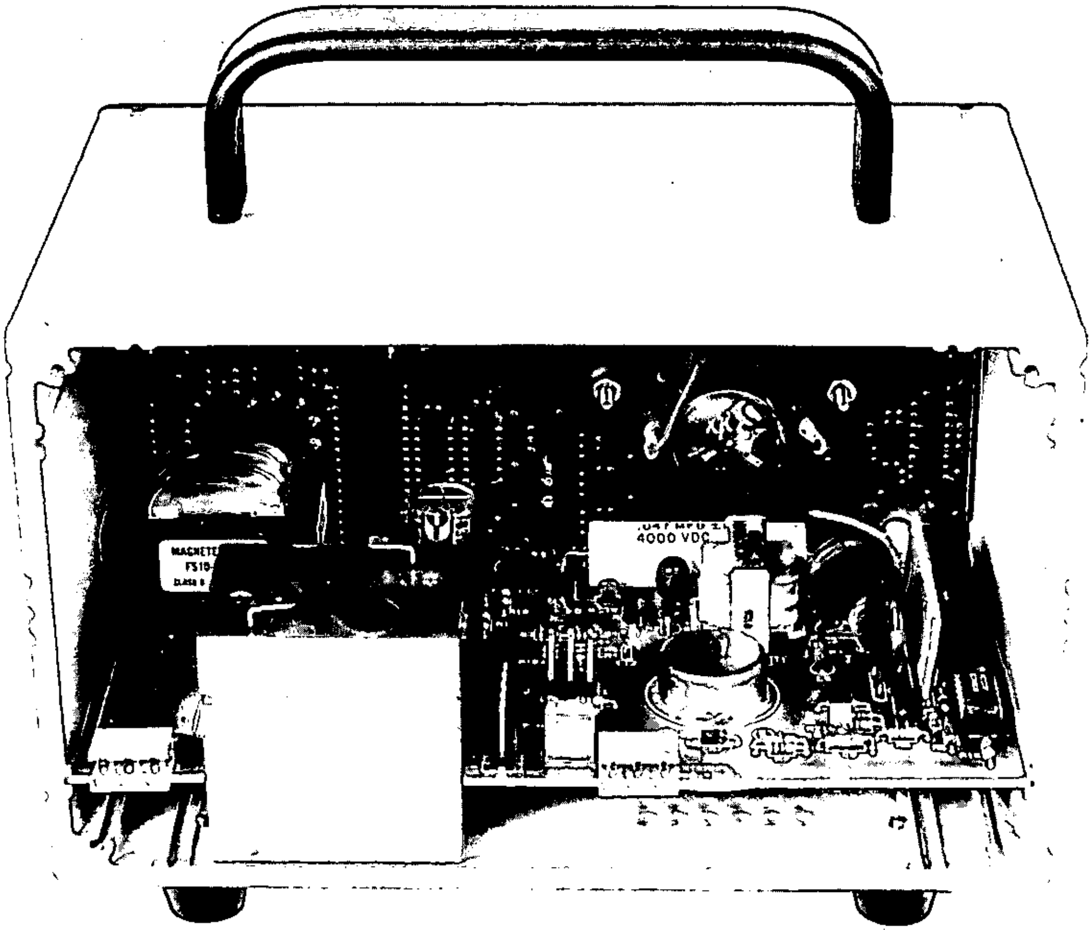
Model RM-14SA Front


Eberline Instrument Corporation
Made in U.S.A.
Santa Fe, New Mexico
Model RM14SA
Serial 115
Battery Fuse ¼ Amp
AC Fuse ¼ Amp
115/230 Vac
60HZ
0.1 Amp
Alarm Output
NC NO COM
Background Update
A B V+

RM-14SA Back



RM-14SA Internals, Front



RM-14SA Internals, Back

SECTION I
GENERAL

A. INTRODUCTION

Congratulations on your purchase of the Eberline RM-14SA. The RM-14SA exemplifies the continuing effort by Eberline to produce enhanced capability replacements for its instrument line, while maintaining the quality and cost effectiveness that Eberline is known for.

B. PURPOSE AND DESCRIPTION

The RM-14SA is a new generation bench top radiation monitor intended primarily for hand frisking applications. Its advanced features and compatibility with numerous detector probes make it a useful instrument for many other applications including low cost area monitors. The RM-14SA is packaged in a rugged extruded aluminum housing which encloses two printed circuit boards, a speaker, and a battery. It is a microcomputer-controlled instrument which utilizes the time proven user interface techniques of an analog meter for data presentation and a potentiometer and rotary switches for instrument control. User definable parameters such as Alarm Setting, Dead Time, and Response Time are retained during power-off conditions.

The standard RM-14SA is a "counts per minute" rate meter. An optional "counts per second" version is available and may be designated as an RM-14SI. However, this manual and the other available options for the RM-14SA apply to both versions. References to counts per second are denoted in parenthesis.

The controls are all located on the front of the instrument with an On/Off pushbutton switch, a Reset switch, a six position range switch, a six position mode switch, and a speaker Volume/Set potentiometer. The meter scale is linear with an upper scale range from zero to five (0-5) cpm, or optional zero to ten (0-10) cps, and a lower scale range from zero to twenty-five (0-25) which is used for parameter display and adjustment. An MHV connector for detector attachment, power-on lights, a reset light, and a red Alarm light are also present on the front panel. The high voltage adjustment potentiometer is accessible through a small hole in the front panel.

C. FEATURES

- Dead Time Corrections
- Background Subtraction
- Detector Saturation Sensing
- Variable Detector High Voltage
- Variable Alarm Setpoint
- Variable Response Time
- Variable Speaker Volume
- Battery Backup
- Single Channel PHA
- High Visibility Alarm Light
- Analog Meter Scale
- Six Decade Range Switch
- Built-in 10 mV Pulse Generator
- Internal Connector for Computerized Calibration
- Optional Alarm Relay Output
- Optional Counts Per Second Meter

- Optional Probe Holders
- Optional Wall Mount Bracket

D. SPECIFICATIONS

Scale Length: 3.5 inches (8.9 cm)

Scale Marking: Black upper scale -- 0 to 5 cpm (or optional 0 to 10 cps);
Red lower scale -- 0 to 25, multi-use

Display Units: Counts Per Minute, or optional Counts Per Second

Range: Switch controlled multipliers of X10, X100, X1K, X10K, X100K, and X1M, yielding 50; 500; 5K; 50K; 500K; 5M counts per minute full scale. (Optional: X0.1, X1, X10, X100, X1K, and X10k yielding 1; 10; 100; 1K; 10K; 100K counts per second full scale.)

Mode: Switch controlled instrument modes:

> Operate: Meter displays count rate.
>
> Battery: Battery [charge] level displayed. Calibration changes less than 10% within battery range limits on meter.
>
> Alarm: 0 to 100% of full scale or disabled
>
> Response: 1 to 25 seconds to 90% of reading
>
> Dead Time: 5 to 250 µs, or disabled
>
> High Voltage: 300 V to 2500 V (100M ohm load)

Input Sensitivity: 1 mV to 50 mV

Linearity: Within ±10% of nominal, typically within ±5%.

Operating Temperature Range: -22°F to +140°F (-30°C to +60°C)

Humidity Range: 0-90% R.H. (non-condensing)

AC Power: 105-125 V, 50-60 Hz at 0.1A (220 V optional)

Battery:

Type: 6 Volt, 900 mA-hour Gel-type battery continuously charged with instrument plugged into line.

Charge Voltage: 6.80 V, Approximately 16 hours to full charge from full discharge with instrument turned off.

Shelf Life: Parameters are retained for more than 6 months.

Operational Backup: Operation on battery backup for a minimum of 8 hours, non-alarmed at full volume.

Detector Connector: MHV

Weight: 5.0 lbs. (2.2 kg)

Dimensions: 7.75 in. Wide x 7.00 in. High x 6.50 in. Deep (19.7 cm x 17.8 cm x 16.5 cm)

SECTION II
OPERATION

A. FRONT PANEL CONTROLS

Operation of the RM-14SA is simple and intuitive. The display and controls are similar, if not identical to those used in traditional frisker units.

1. On/Off

The On/Off pushbutton switch turns the unit on or off. The switch has two built-in LEDs: green for indicating that the unit is line powered, and yellow for indicating that the battery is the power source for the instrument.

2. Reset

The Reset pushbutton switch is used to reset the meter reading to zero thereby clearing an alarm. It is also used to allow the setting of parameters, such as the Alarm level and Dead Time, and for displaying the actual (gross) count rate while a background update is in progress.

3. Volume/Set

The Volume/Set potentiometer is used to vary the speaker volume and to adjust the parameters of Alarm level, Response Time, and Dead Time.

4. Mode

The mode rotary switch is used to select each of six possible meter displays. The selections are: Operate (the current net count rate), Battery, Alarm, Response, Dead Time, and High Voltage.

5. Range

The range rotary switch is used to select the meter scaling multiplier for displaying counts per minute (or counts per second) data in the Operate Mode. The scaling multiplier of X10, X100, X1K, X10K, X100K, and X1M (X0.1, X1, X10, X100, X1K, X10K for cps option) must be multiplied by the meter reading to obtain the proper count rate.

B. INDICATORS

On the front face of the RM-14SA are several light emitting diode (LED) indicators which the processor uses to flag a number of different status conditions. Table 2-2 lists the LED states and the corresponding instrument status.

C. INTERNAL CONTROLS

All internal controls are accessed by removing the front panel except for the high voltage potentiometer which can be accessed through a small access hole in the front panel, and the battery charge adjustment which requires removal of the back panel.

1. DIP Switches

A four-switch package is located in the lower right hand corner of the Main printed circuit board. These configuration switches are used to enable or disable several features. A switch number appears above each switch and the Open position is indicated below the switches. To Open a switch, use a pencil or some other pointed instrument and press the lower dot on the switch down. When Open, the lower part of the toggle will be flush with the switch face. To Close a switch, press the upper dot. When Closed, the upper part of the toggle will be flush with the switch face.

The functions defined by the switches include which parameters may be adjusted from the front panel, whether alarms are latching or not, and background subtraction operation. Three of the switches are dual-function, assuming one meaning during configuration, and a different meaning during operation.

The Defaults switch (SW3) is used to select either *Operate* mode or *Defaults/Configuration* mode. When Defaults switch (SW3) is Open, the instrument is in the normal Operate mode. When Closed, the Defaults/Configuration mode is enabled.

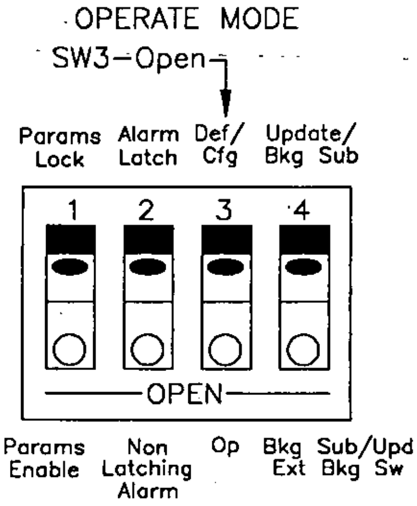


Figure 2-1

OPERATE MODE (SW3 OPEN)

In this mode, switches 1, 2, and 4 assume the following primary functions:

Switch 1 - Front Panel Lockout
When Open front panel parameter adjustments will be allowed. When Closed (*Lock* position), adjustment of the Alarm Setpoint, Response Time, and Dead Time will be inhibited.

Depending on the configuration setup, this switch when Closed, could lock only Alarm and/or Dead Time parameters. See Defaults/ Configuration Mode which follows.

Switch 2 - Latching Alarm
When Closed (*Latch* position), alarms will be latching and may be cleared only by pressing the Reset switch. When Open (*Non-latching*), alarms will clear automatically whenever the count rate drops below the alarm setpoint.

Switch 3 - Defaults
This switch must be Open for normal operation.

Switch 4 - Background Update
When Closed (*Update Bkg.*), will cause the instrument to begin taking a new background reading. When Open, *(Subtract Bkg)*, the last background reading will be subtracted from the gross count rate and the net count rate displayed on the meter. If the background subtract feature is not to be implemented keep this switch Open when operating the instrument.

Depending on the configuration setup, the switch position functions could be reversed during operation. This feature provides additional flexibility when using external background subtraction switches (eg., a mat switch). If *Normally-Open* polarity was selected, then the Open position will cause a background update. If *Normally-Closed* contacts were selected, then the Closed position will cause a background update. In both cases, the opposite switch position will cause background subtraction to be performed. See Defaults/Configuration Mode which follows for setup information.

NOTE
When the instrument is updating the background count, the meter will read zero (the net count rate). Pressing the Reset switch will light the green Reset LED and cause the gross count rate to be displayed. Pressing Reset again will turn the green LED off and return the display mode to net count rate. This applies to units with the lighted background switch or an external background subtraction switch as well.

DEFAULTS/CONFIGURATION MODE (SW3 CLOSED)

When closed, the Defaults/Configuration switch (SW3) causes background subtraction to be disabled and the instrument to be initialized with default parameters for Response Time, Alarm Setting, and Dead Time. In addition, the high voltage reading will be flagged as "unknown" and a meter calibration value of 4.00 (8.00 for cps option) will be output to the meter. (See Section IV.D.2 regarding meter calibration.)

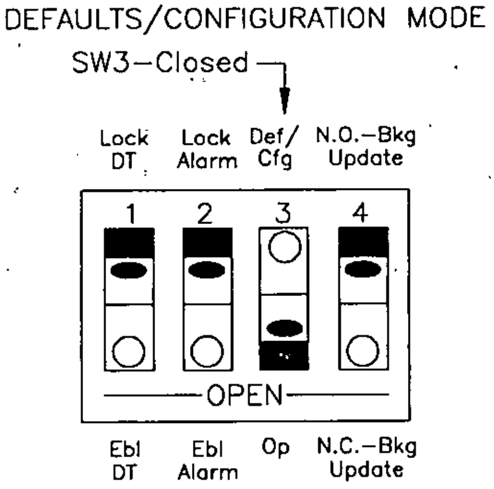


Figure 2-2

When SW3 is Closed *(Defaults/Configure* position), editing configuration is enabled and switches 1, 2, and 4 take on the functions described below:

Switch 1 - Dead Time Lockout
This switch controls lockout of the front panel adjustment of Dead Time. When the instrument is configured with this switch in the Closed *(Lock DT)* position, front panel adjustment of Dead Time only can be prevented. When Open *(Enable DT)*, the Dead Time value may be changed from the front panel during Operate Mode, if the Parameters Lockout switch (SW1) is left Open.

Switch 2 - Alarm Lockout
This switch controls lockout of the front panel adjustment of the Alarm Setpoint. When the instrument is configured with this switch in the Closed *(Lock Alarm)* position, front panel adjustment of only the Alarm setting can be prevented. When set to Open, *(Enable Alarm)* the alarm limit may be changed from the front panel if the Parameter Lockout switch (SW1) is left Open in Operate Mode.

NOTE

> If both SW1 and SW2 are left in the Closed position during Configuration Mode (SW3 Closed), then only the Response Time adjustment is possible with the Parameter Lockout switch Closed (*Lock* position) in the Operate Mode (SW3 Open). If both SW1 and SW2 are left in the Open position during Configuration Mode (SW3 Closed) then all front panel adjustments (including Response Time) will be prevented when the Parameter Lockout switch (SW1) is in the *Lock* position in Operate Mode (SW3 Open). Refer to Table 2-1.

All parameters may be adjusted from the front panel when the Parameter Lockout switch (SW1) is left Open in normal Operate Mode.

Switch 4 - Update Switch Polarity
This switch defines the polarity of the Background Update switch and is particularly useful when external background switches are implemented. Open this switch during configuration (N.C.-Bkg Upd position) to cause the background subtraction value to be updated when the Background Update switch is Closed. Closing this switch during configuration (N.O.-Bkg Upd position) will cause background subtraction to be performed when the Background Update switch is Open. In short, set this switch to the position where background

subtraction should occur (opposite the position where a background update should occur). As an example, if a floor mat is to be used for the Background Update switch (floor mats are Normally-Open type switches which close when stepped on), then background updates should occur when no one is standing on the mat, that is, when the contacts are open. Therefore, the Update Switch Polarity should be set to Closed *(N.O. Update)* during configuration. In most other cases, and in applications where background subtraction will not be used, this switch should be left Open *(N.C. Update).*

To Lock out front panel adjustment of:	**Perform this sequence:**			
Dead Time, Alarm and Response Time	Close SW3	Open SW1 & SW2	Open SW3	Close SW1
Dead Time	Close SW3	Close SW1	Open SW3	Close SW1
Alarm	Close SW3	Close SW2	Open SW3	Close SW1
Dead Time and Alarm	Close SW3	Close SW1 & SW2	Open SW3	Close SW1
None	Close SW3	Open SW1 & SW2	Open SW3	Open SW1

Table 2-1 Parameter(s) Lock Options

Configuration Sequence

The following summarizes the configuration procedure. Refer to Figures 2-1 and 2-2.

NOTE

> Closing SW3 (Default/Configuration position) allows "editing" the configuration setup. Opening SW3 (Operate position) "enters" the configuration selected by the position of switches 1, 2 and 4. All parameters will be reset to default values.

- Determine if Dead Time and/or Alarm parameters are to be locked, while allowing Response Time adjustment. See previous descriptions on SW1 and SW2 functions during configuration and refer to Table 2-1.

- Determine if Background Subtraction is to be implemented with an external switch where a particular polarity is required for updating background. See previous descriptions on SW4 functions during configuration.

- If Dead Time or Alarm parameters are not to be individually locked or all parameters are to be locked and background subtraction is not implemented, then see the preceding description on **Operate Mode (SW3 Open)** for normal operation setup. Defaults/Configuration with SW3 Closed shouldn't be necessary since those functions won't be implemented. Refer to Figure 2-1 Operate Configuration and set switches accordingly.

- If any of the functions mentioned in the previous paragraph are to be implemented then **CLOSE SW3 to enable or "edit"** selection of the desired functions. This initiates the *Default/Configuration Mode.*

- Close SW1 to Lock Dead Time parameter only.

- Close SW2 to Lock Alarm parameter only. (Closing both SW1 and SW2 will allow only Response Time adjustment when Parameters Lock switch is Closed during Operate Mode. See Table 2-1.)

- Close SW4 to have External Background Switch update background on normally-open (N.O.) switch contacts. If SW4 is left in the Open position then background updates will occur on normally-closed (N.C.) switch contacts. In either case, the opposite switch position will then cause background subtraction to occur. Refer to Figure 2-2.

- When satisfied switches 1, 2 and 4 are specifying the desired configuration for Dead Time Lockout, Alarm Lockout, and Background Update Polarity, **OPEN SW3 to "enter"** the configuration settings and return to *Operate Mode.*

- If SW1 is Closed, Open it now and set Alarm, Response Time and Dead Time parameters. (Calibrate to detector if necessary for Dead Time, see Section IV - Maintenance).

- When all parameters are set, Close SW1 *(Parameters Lock)* if any or all parameters are to be locked. Which parameters are locked depends on the position of SW1 and SW2 during configuration. See Table 2-1.

- Close SW2 *(Alarm Latch)* if Alarms are to latch, that is cleared with the Reset switch rather than automatically cleared when count rate drops below Alarm set point.

- Close SW4 *(Update/Bkg Sub)* to obtain or update the background subtraction value. Open SW4 to subtract the background value from the gross counts. Open SW4 to enable the External Background Subtract switch to operate as selected during configuration. This applies to the Lighted Background Subtract switch option (RM14SA OPT5) as well.

Additional information on general operation and use of dead time correction, background subtraction and setting of parameters follows in Section II - E. Instrument Operation.

2. PHA/Gross

The PHA/Gross switch (SW9) enables or disables the single channel analyzer. With the switch set to P (PHA on), only detector pulses of amplitude greater than the threshold setting but less than the window setting will be counted. With the switch set to G (Gross counts), all pulses of amplitude greater than the threshold setting will be counted.

3. Gain

The Gain potentiometer (R25) adjusts the amplifier's gain. Increase the gain by turning the potentiometer clockwise.

4. Threshold

The Thld potentiometer (R18) adjusts the discriminator threshold level. Lower the threshold by turning the potentiometer counter clockwise.

5. Window

The Win potentiometer (R19) adjusts the PHA window width. Increase the window by turning the potentiometer clockwise.

6. HV Adjustment

The HV potentiometer (R12) adjusts the high voltage level. The high voltage is adjustable from approximately 300 volts to 2500 volts. Turn the potentiometer clockwise to increase high voltage. If the unit is in High Voltage mode, the high voltage will be displayed as it is adjusted. When decreasing high voltage, both the meter response and the actual high voltage will lag the counter clockwise adjustment. Due to electrical characteristics, the rate at which the high voltage can be decreased will be slower than the rate at which it can be increased.

7. Meter Calibrate

The Meter potentiometer (R47) calibrates the meter to display count rates correctly. Verify that jumper JP2 is set to position 2 for a counts per minute meter (position 1 for counts per second meter.) Calibrate the meter by closing the Defaults switch (SW3) and adjusting the potentiometer until the meter reads exactly 4.00 (8.00 with optional cps meter). The Defaults switch should then be returned to the Open (Operate) position.

WARNING

> Meter calibration will cause instrument configuration parameters to be lost when the Defaults switch is closed. See Section II.E.4.

8. Comparator Calibrate

The Comp Cal potentiometer (R5) calibrates the comparator circuit which allows the meter to display the high voltage level correctly. Calibrate this potentiometer after setting the Meter Cal potentiometer. Begin by disconnecting the detector and setting the high voltage (R12) to 2000 volts (with probe disconnected). Adjust the Comp Cal potentiometer (R5) until the meter agrees with the 2000 volt output setting. Once calibrated, re-adjust the high voltage setting to match the detector probe to be used.

9. Charge Level

The Charge potentiometer (R19) is located on the PS/HV circuit board and provides adjustment of the battery charge voltage. For a fully charged battery, the nominal charge voltage is 6.80 volts (measured at the battery terminals). The charge voltage will drop to approximately 6.5 volts when the unit is turned off.

D. PREPARATIONS

Before turning the unit on, plug the AC cord into 115 V, 60 Hz line (220 V, 50 Hz for instruments wired for the 220 V option.)

WARNING

> If the high voltage setting is unknown, the detector should remain disconnected until the high voltage is matched to the detector.

Select the Operate mode.

E. INSTRUMENT OPERATION

1. Startup

Turn the instrument on by depressing the On/Off pushbutton. The green AC On LED should light. Once On, if the green Reset LED is blinking twice a second, then the memory has been reset and the instrument is using default settings for Alarm, Response Time and Dead Time. Setting any one of these three parameters will stop the blinking (see Section II.E.4). A much slower frequency blink (about once every five seconds) indicates the instrument is configured for background subtraction and is displaying the net count rate.

NOTE

Holding the Reset switch down while turning the unit On will cause a sequence of tones to be generated. These tones indicate the program firmware version of the instrument (e.g. Ver. 1.1 would produce a long tone followed by a short tone). The version tone sequence will repeat as long as the Reset switch is held down.

2. Operation Check

Set the mode to Battery and verify that the meter reads in the red "Battery" zone indicating the battery charge voltage is correct.

Unplug the AC cord and verify the actual battery voltage. A reading near the lower end of the zone indicates the battery is almost discharged and the unit should be plugged into AC. A low battery will take about 16 hours for a full charge.

Using a digital voltmeter and high voltage probe, set the mode to High Voltage and verify the meter displays the correct high voltage setting (±5%). If the meter reading is off, see Section IV.D on meter calibration. Set the mode back to Operate.

Adjust the speaker volume to a comfortable setting and set the range to X10. Place a check source next to the detector so that an up scale reading is achieved. Adjust the range until the reading is on scale.

Push the Reset switch and note the reading will drop abruptly, then return to its previous position as Reset is released. The Response Time may be adjusted to provide the best compromise between the response to sudden changes and the damping of statistical fluctuations.

Test the alarm by setting the alarm setpoint below the current reading. (See Section II.E.4 for help.) Return to operate mode and an alarm should occur. While in an alarmed condition, the Alarm LED will be lit and the speaker alarm tone of 1000 Hz will sound. Push the Reset switch and the reading will be zeroed, silencing the alarm. As the reading again exceeds the setpoint, the alarm will again trip.

Move the check source away from the detector. The alarm should be cleared automatically as the reading drops below the alarm setting. If not, the internal Alarm Latch switch (SW2) is set to latch alarms, requiring alarms to be cleared by pressing the Reset switch.

3. Reading the Meter

The meter face contains two scales: one black 0 to 5 scale used for count rate readings in counts per minute (or optional, 0 to 10 for counts per second) and a red 0 to 25 scale which is used for Response Time, Dead Time and High Voltage readings. In addition, a red battery zone is also present which indicates the voltage region where the battery will provide reliable instrument operation. In order to interpret the count rate correctly, the values on the black scale must be multiplied by the proper factor. In the Operate mode, the multiplier of 10, 100, 1000, 10000, 100000, or 1000000 (or 0.1, 1, 10, 100, 1000, or 10000 for counts per second), is determined from the selected range.

Therefore, a reading of 3.2 on the X100 range should be interpreted to mean 3.2 times 100, or 320 counts per minute (or cps with optional meter). For the Response Time, Dead Time and High Voltage modes, the multipliers and units of measurement are printed on the meter face: Response Time is in seconds on the red scale and requires no multiplier; Dead Time is in microseconds and a multiplier of 10 must be used; High Voltage is in volts and a multiplier of 100 must be used. In the Alarm mode, the setting is defined by a position on the meter and uses the multiplier for the range selected. The alarm setting remains at the same meter position when changing ranges.

4. Setting Parameters

During the time the instrument is turned off, power to the processor is maintained so that the user defined parameters are not lost. These parameters consist of the Alarm Setting, Response Time, Dead Time, most recent High Voltage value, and the most recent Background Subtraction value. Should any of these parameters be corrupted, for example by loss of battery power, the RM-14SA will sense the condition, restore default parameters, and indicate that it is out of calibration with a blinking Reset LED. If this condition occurs, the Default Configuration procedure must be performed before proceeding (See Section II.C.1). While in Operate mode, the LED will blink several times each second until new calibration parameters are set. An infrequent blinking indicates background subtraction is in effect and should not be confused with the rapid blinking indicating the usage of default parameters.

The following default parameters are restored by the program on a cold start or whenever SW3 (Defaults/Configuration) is closed:

Alarm Level	DISABLED (>F.S.)
Response Time	2 seconds
Dead Time	DISABLED (0μs)
High Voltage Readout	UNKNOWN
Background Subtract.	DISABLED

Although the high voltage setting is defined by a hardware adjustment and is not alterable through the program, the high voltage value is measured whenever the unit is in High Voltage mode and recorded as soon as the mode is changed. New background subtraction values are recorded continuously whenever the Bkg Sub switch (SW4) or the optional External Background Subtraction Switch is in the Background Update position.

The procedure for defining the Alarm, Response Time and Dead Time parameters may be described as follows:

a. Set the mode switch to the position of the parameter to be changed. The meter will display the value of the current setting.

b. Press the Reset switch. The green Reset LED should light indicating the parameter may now be adjusted. If the LED is not lit, the internal Lock switch (SW1) has been closed preventing the alteration of that parameter. Opening the Lock switch (SW1) will always allow parameter adjustment.

c. With the green Reset LED lit, watch the meter and adjust the Volume/Set knob to specify the new parameter value. Due to meter non-linearity, the value displayed may disagree slightly from the actual stored value.

NOTE

In the event that a parameter was inadvertently adjusted, the old parameter value may be restored by pressing the Reset switch again. The green LED will go out and the old value will again appear on the meter.

d. Record the new setting by changing the position of the mode switch.

5. Dead Time Correction

The RM-14SA is capable of correcting readings for losses due to detector and circuit dead time (i.e., the amount of time for the detector and detector circuitry to recover from a pulse before another pulse can be sensed). At high count rates the number of missed counts can be significant, but, by using a special algorithm which accounts for the missed counts, the RM-14SA will correct the reading. Calibration of the Dead Time parameter is discussed in the Maintenance Section 4.E., Calibration with a Detector. Because dead time losses are only significant at higher count rates, the RM-14SA will not correct for dead time on the lowest two ranges (X10 and X100 ranges or X.1 and X1 with CPS meter.)

6. Using Background Subtraction

The internal Bkg Sub/Upd configuration switch controls whether the RM-14SA is in the measure background mode or in the normal operate mode. The PS/HV printed circuit board provides a rear panel terminal strip so that this switch can be remoted by the customer. Polarity of the switch is determined during configuration. During Defaults configuration, the position of the Update Polarity switch will become the "subtract background" position. See Default/Configuration in Section II.C.1. Once Defaults configuration is complete, toggling the switch will cause a background update. When this switch is in the update background position, the meter reads zero regardless of the count rate. The gross and background count rates are being measured simultaneously, hence the displayed net count rate is zero. The value of the background count rate can be viewed in this instance by depressing the Reset switch. When the Bkg Sub switch is moved to the subtract background position, the most recent value of the background is saved and used in all subsequent net count rate calculations. In order to determine what value to subtract, a background update must take place before background subtraction is possible. While background subtraction is in effect, the speaker will click at the net count rate.

The instrument response time must be considered when performing background updates and/or viewing the background value. During background updates, the Response Time is ten times the normal operate Response Time setting. Insufficient allowance for response time will result in inaccurate background measurements. Care must be taken to allow ample time for the instrument to respond to changes in count rate before the Background Update switch can be toggled to save the new background reading.

Typically, at least 2 response times should be allowed for the background to stabilize. For instance, if the normal operate Response Time setting is 10 seconds, the user should allow a 200 second background update. This may be reduced in areas of fairly stable background.

NOTE

The Background Update switch (SW4) must be in the Open position when operating with the optional Lighted Background Subtraction switch or with an external background subtract switch.

7. Upscale Readings

In the event a count rate is measured that is too high to be displayed on the current range setting, the meter will indicate a value that is above the end of the meter scale. When this occurs, switch to the next higher range to bring the reading on scale.

8. The Overrange Condition

An overrange condition occurs when the RM-14SA records a high count rate requiring excessively large compensation for dead time. When this condition is met, the Alarm LED will blink rapidly in conjunction with an alarm tone. Once an overrange condition has occurred, it can only be cleared by turning the instrument Off, then back On. Because an overrange condition is only necessary when dead time is being applied, the RM-14SA will not overrange when the Dead Time is set to zero, or when the instrument is set to the bottom two ranges which do not use dead time correction.

NO.	INDICATOR	STATE	MODE	CAUSE
1.	Green - AC On (On/Off Switch)	ON	ALL	Instrument power is being supplied from 120 Vac line.
2.	Yellow - Battery On (On/Off Switch)	ON	ALL	Instrument power is being supplied from the battery.
3.	Green (Reset Switch)	blinks every 1/2 sec	Operate	Instrument is using default parameters and must be calibrated.
		blinks every 5 sec	Operate	Background subtraction is enabled and meter is displaying net counts.
		ON for approx 5 sec	Startup only	Background subtraction is enabled and meter is displaying the subtraction value while LED is lit.
		ON	Alarm, Response Time or Dead Time	A parameter is being changed. Set new value with Volume/Set then change mode, or restore old value pressing Reset.
		ON	Operate with Bkg Sub	While updating background, the Reset was pressed. Meter is displaying gross count rate. Press again to clear condition and wait 2 response times.
4.	Red Alarm	ON	Operate	Instrument is in an alarm condition. Clear alarm with a Reset.
		blinks	Operate	Instrument is in count rate overrange condition. Count rate is too high for dead time correction. Turn unit Off then back On to clear the condition.
	NOTE: Speaker alarm tone will sound whenever the red alarm LED is lit.			
5.	Meter	above scale	Operate	Range setting is too low for reading. Increase range.
		above scale	Alarm	Alarm setting is set to maximum (disabled).
		reads 4.00	ALL	Defaults switch (SW3) is Closed forcing the meter calibration output.

Table 2-2, RM-14SA Indications

SECTION III
OPERATION

A. GENERAL

The RM-14SA employs microprocessor technology together with conventional controls to produce a digital instrument with the look and feel of an analog design. The design objective of analog "ease of use" combined with microprocessor "flexibility and power" have been fulfilled in the RM-14SA. The variable high voltage and adjustable dead time give the RM-14SA the capability to be used with a variety of detectors, and over a large range of count rates. The Power Supply/High Voltage circuit board provides the two regulated 5V supplies required by the Main circuit board as well as some reset circuitry for starting the microprocessor running, and an adjustable high voltage supply. The Main circuit board contains the processor, counting circuitry, and controls user input and output functions.

B. FUNCTIONAL THEORY - MAIN CIRCUIT BOARD

Functional theory of the RM-14SA can be broken into several functional subsections:

1. Detector

The detector is selected to optimize the accuracy of the reading for the radiation of interest. It provides the pulse signal to the electronics for counting. The pulse rate from the detector is proportional to the radiation field measured by the detector.

2. Amplifier/Discriminator

The amplifier is a linear, variable-gain, multistage design. It amplifies the signal from the probe to a usable level at the amplifier output. The discriminator provides a signal on its output only if the signal from the amplifier exceeds the adjustable threshold. This, in turn, provides a means for counting only radiation signals and rejecting noise. In the case where Pulse-Height-Analysis (PHA) is selected, the signal must also fall within an amplitude window in order to be passed by the discriminator. This provides a means for counting only a specific range of signal amplitudes which are proportional to the energy of detected radiation. The PHA operation allows the measurement of a specific energy window.

3. Speaker/Alarm

The speaker/alarm section provides an audible "click rate" from the speaker, which is equal to the output of the amplifier/discriminator or net counts during background subtraction. When alarmed the speaker emits a continuous tone.

4. Controls

The controls section provides the means of setting how the instrument operates. Operator inputs are sensed by the microprocessor through the switches and potentiometers.

5. Outputs

The outputs section provide the indications to the operator of the state of the instrument. Visual indications of the instrument state are provided to the operator by LED indicators and the meter.

6. Microcomputer

The microcomputer section consists of the microcomputer and its clock, reset, and power-down circuitry. The microcomputer controls the instrument operation, the interface with the operator, the counting of detector pulses, the calculations on the data, and the display of the data to the operator in a usable format.

C. FUNCTIONAL THEORY - PS/HV CIRCUIT BOARD

1. High Voltage Supply

The high voltage supply provides the bias voltage to the detector as required for proper operation. The high voltage is regulated to enhance operating stability and adjustable to provide the correct operating voltages for a large selection of detectors.

2. Power Supply and Battery Charging

The power supply and battery charging section regulates and provides power to the instrument from either a 115/230 volt line source or the battery. While operating on 115/230 volt line input, the battery charge circuitry provides the required charge voltage to the battery.

D. OPERATIONAL THEORY

1. Power Supply and Battery Charging

The RM-14SA is supplied power from a 115 Vac (or optional 230 Vac) line source, and by a 6 volt DC "Gel-Cell" type battery. During operation on the AC line source, the battery is being charged. When AC power is removed from the unit, power is supplied from the battery. The power supplies and high voltage circuitry are located on the PS/HV circuit board. Transformer (T2) and diode rectifier (A3) provide the unregulated 15 volt input to the battery charging regulator (A4). The 6 volt charging regulator is referenced above ground to produce a charge voltage of 6.75 volts on the battery (+VBAT). When AC power is removed, diode CR6 prevents feedback to ground from the battery through voltage divider R17/R18 and charge level reference R19.

Beyond the battery lie two 5 volt regulators (A5 and A2) which supply power to the processor and relay driver (+V1), and to the remaining components on the board (+V2). The +V1 supply is always present and maintains the memory in the processor during power-down mode (the processor is unpowered only when the line source is removed, and the battery is disconnected or the battery fuse removed). The +V2 supply is controlled by Q3, which is indirectly switched on/off by the processor power-down sequence. This causes the +V2 supply to be removed when the unit is turned off. Q4 serves as a switch to discharge capacitor C11 rapidly on instrument turn off.

2. High Voltage Supply

Transistor Q2 and transformer T1 form an oscillator circuit. The voltage of the secondary of T1 is highly stepped up. CR1, CR2, CR3, C4, and C5 form a voltage tripler circuit. R2, C2 and C3 help filter this voltage.

R1 is a very high impedance divider used in a feedback loop to control and regulate the high voltage output. A1 pin 3 is the input to an amplifier, which is used as a low output impedance follower of the divider signal.

A1 pin 1 drives amplifier input A1 pin 6, while the input reference is set by the HV potentiometer (R12) on the main circuit board. The output of this stage drives Q1, which controls the level of oscillation of the high voltage circuit, thereby completing the feedback loop. A1 pin 1 also drives an external comparator, which is used by the processor to match the meter output to high voltage, thereby displaying the high voltage on the meter.

3. Amplifier

All remaining functions are performed by the RM-14SA main circuit board. Transistor Q1 and the two operational amplifiers of A2 form the RM-14SA amplifier section. Resistors R28 and R29 set a direct-current reference for the operational amplifiers. A feedback loop through

R31 and R26 provides a direct-current bias for the entire amplifier. The gain potentiometer (R25) is normally set at maximum gain (fully clockwise) except when the instrument is required to be less sensitive than is possible using Thld potentiometer (R18) alone.

4. Discriminator

The amplifier output (A2 pin 7) goes through C10 to comparator input pins 12 and 14 of A2 and is direct-current biased by the wiper of the Thld setting (R18). The threshold comparator reference input (A2 pin 11) is biased to 2.0 volts yielding a threshold range of 1.0 volt. The threshold comparator will then pass any amplifier pulses of amplitude greater than the 2.0 volts minus the threshold bias. The window comparator reference input (A2 pin 15) is direct-current biased between 2.0 and 3.0 volts by the Win potentiometer (R19) wiper. The window comparator will pass any amplifier pulses of amplitude greater than the window reference minus the amplifier output bias (a range of from 0.0 to 2.0 volts).

The threshold comparator output (A2 pin 10) passes through one propagation delay (A4) and clocks A3 pin 11, a D-type flip-flop, and three further propagation delays (A4 pins 6, 11, and 8). The output of the fourth delay (A4 pin 8) clears the output of the flip-flop yielding a very narrow output pulse (A3 pin 9) of about 60 nanoseconds.

When PHA counting is selected by setting SW9 to P, the output of the window comparator clocks A3 pin 3 and generates a premature CLEAR of the output A3 pin 9, thereby preventing a pulse from being passed.

In addition to the narrow output pulse (A3 pin 9), the discriminator provides a second, divide-by-two, output from A5 pin 6 which drives the processor counter.

5. Speaker/Alarm

Two sections of A8 (pins 8, 9, 10, and 11, 12, 13) form a free running oscillator of about 1 kHz. This oscillator drives the speaker. The other two sections make up a monostable trigger which turns on the oscillator for about 2 milliseconds each time a detector pulse arrives. Because the discriminator output pulse is quite narrow, the signal is integrated by R44 and C22 to provide enough active time on the input A8 pin 6. The speaker oscillator may be disabled from the processor by setting the port P3.5 output bit high. The processor may also force a continuous alarm tone by writing port P0.6 low, thereby latching the active low monostable output.

Speaker volume is controlled by Volume/Set potentiometer R37, the wiper of which drives the base of Q3 regulating speaker drive. The volume controls are bypassed and the speaker operates at full volume whenever the alarm (port P0.6 bit) is triggered, saturating Q2.

6. Controls/Outputs

The Volume/Set potentiometer, in addition to functioning as the speaker volume control, serves as a control for adjusting the meter reading while a parameter is being set by the operator. This is accomplished in an indirect manner. The wiper of R37 sources voltage divider R36-R38 which provides a variable voltage reference to comparator reference pin 15 of A1. The comparator input pin 14 of A1 is the meter output (A7 pin 1) amplified (A1 pins 5, 6, 7) to a signal in the range 0.0 to 2.5 volts, and provides the means for the processor to match the meter reading to the Volume/Set position. The processor accomplishes this by ramping up the D/A (A7) output until comparator output A1 pin 16 goes high. The D/A is then ramped down until the comparator output goes low. Using this algorithm, the processor is able to track the adjustment of the Volume/Set potentiometer.

The mode and range switches are six position break-before-make types with wipers that short between adjacent pins. Three processor port bits are used to sample the position of each switch. The algorithm used to determine switch position incorporates configuring some bits as outputs and writing them high, while reading the other bits as inputs.

The Reset switch is a simple momentary pushbutton which, when depressed, pulls processor port bit P2.6 low. A green Reset LED is controlled by another processor output port bit (P0.7) which drives the open-collector output pin 12 of A6.

The On/Off switch is sampled via processor port bit P2.7, while the processor is running. When the bit is observed to go high, the processor executes the power-down sequence and shuts the instrument off. Two light emitting diodes provide indication of the power source from which the instrument is operating. The green "AC On" LED is sourced directly from the battery charge regulator on the PS/HV board, while the yellow "Battery On" LED is sourced by the +V1 supply but switched by open-collector output pin 10 of A6.

The meter is driven by writing an 8-bit value out processor port P1 to digital-to-analog converter A7. The D/A output to the meter is not amplifier driven. The current out is a function of the +V2 supply voltage and the code selected internal resistors. R48 and the Meter potentiometer, R47, are in parallel with the meter so that the full scale voltage drop of the meter does not vary. An amplifier scales the meter output voltage into the range 0.0 to 2.5 volts for use as a reference input into the high voltage and "set" comparators (A1 pins 12 and 14). The meter output amplifier (A1 pin 7) is calibrated by the Comp potentiometer (R5) so that the high voltage reads correctly on the meter when the comparator output (A1 pin 10) is toggling.

The Alarm LED (CR2) is driven by the same open-collector output (A6 pin 11) that causes the speaker volume bypass to occur on alarms.

7. Microcomputer Circuitry

The microcomputer system consists of the processor (A10), clock circuitry (X1, C27, C28), on the main board, and the power-down circuitry (R13, Q4), and power-up section (Q3, C11, R10, R11, CR4, CR5) on the PS/HV board.

a. Clock

The crystal oscillator (X1, C27, C28) provides the clock input to the processor pins 18 and 19. The frequency of 7.3728 MHz provides the means to generate the 9600 bit per second (baud) communications rate at the processor serial output pin, as well as providing a sufficient time base for other program requirements.

b. Power Down

The power-down-up circuitry works as follows:

Whenever On/Off switch SW5 closure is sensed, the processor disables interrupts and writes all port bits to the power off state (low). Next, the processor calculates a checksum on internal memory so that a loss of processor power (hence memory loss) can be determined on startup. SW5 is then sampled to wait for switch release, at which point the power-down is performed by setting P3.7 (PWR2).

Setting PWR2 causes a clear of all open-collector outputs of A6.

On the PS/HV board, Q3 is then shut off as A6 pin 9 goes to a high impedance state, removing power from regulator A2, hence the +V2 bus. This powers down all devices on the board with the exception of the processor and the A6 driver (although its outputs are disabled). In addition, Q4 will be briefly turned on, discharging C11.

The processor enters a power-down mode to reduce current requirements during the Off state. A processor RESET is required to bring the processor out of the power-down mode.

c. Power Up

The power-up commences with the closure of On/Off switch SW5 as follows:

Closure of SW5 grounds the CLR and OE pins of A6, which enables the open-collector output on pin 9.

On the PS/HV board, Q3 is turned on when the open-collector output, pin 9 of A6, becomes active. This enables power to 5 volt regulator A2 and brings up the +V2 supply.

Meanwhile, C12 passes a spike caused by Q3 being switched on, through R14 and CR5 and generates a processor RESET on pin 9 of A10. The RESET brings the processor out of power-down mode and program execution begins.

8. Program Theory

a. General

The RM-14SA program is designed to reduce processor current requirements by executing program a small fraction of the time, and spending the remainder in a power saving "idle mode". This is accomplished by executing most program instructions under a timer interrupt which occurs several times a second. On termination of the interrupt, the "idle mode" is entered. Execution of instructions will then resume only after the specified time defined by the timer preset. Performance analysis has shown that the processor is executing instructions only 2% of the time available.

b. Startup

The program performs one of two different startup sequences depending on the results of a checksum test on internal memory. If the checksum test verifies that memory contents have not been altered during power-down, a "warm start" sequence is performed. Otherwise, memory contents are assumed to be destroyed and a "cold start" sequence is performed.

During a cold start all internal memory locations are cleared and a set of default values loaded to define the instrument operation parameters. A cold start is followed by a warm start.

During a warm start, the I/O port bits are initialized as are the internal timer values, flag bits, and other internal registers.

c. Operate Mode

In Operate mode, the counts are read at the start of every timer interrupt. The timer is then reloaded, the counter zeroed, and both timer and counter restarted. The counts are adjusted for dead time, a weighted average count rate calculated, and any background value subtracted. The value is written to the D/A for display on the meter and any alarms or overrange conditions are then annunciated by turning the alarm on.

Timer durations are defined by the current range setting, and vary from 59 to 96 milliseconds in length.

d. Battery Mode

In Battery mode, as well as all other non-Operate modes, timer interrupts occur every 5 milliseconds. The D/A output is zeroed, then incremented each interrupt until the battery voltage comparator output toggles. The D/A value is then incremented or decremented as required by the state of the comparator. This produces a meter reading that is proportional to the battery/charge level.

e. Alarm Mode

In Alarm mode, the program writes the value of the current Alarm Setting to the D/A. Each interrupt the switches are tested for operator input. When the state of the Reset switch is seen to change, the program writes the green Reset LED bit high, turning the LED on. In this adjust mode, the meter match algorithm described above is used to match the D/A output to reflect the value of the Volume/Set potentiometer. Once the mode setting is changed, the latest D/A value is saved as the new parameter value and the Reset LED is turned off.

f. Response Mode

The program treats the Response Time mode identically to the Alarm mode, by displaying the current Response Time value, allowing it to be adjusted, and saving the new value.

g. Dead Time Mode

The program treats the Dead Time mode identically to the Alarm mode, by displaying the current Dead Time value, allowing it to be adjusted, and saving the new value.

h. High Voltage Mode

The High Voltage mode is treated similarly to the Battery mode, with the meter being matched to the input value of the high voltage comparator. On a change of mode switch position, the current D/A output value is saved to provide a record of the high voltage. The high voltage value is reported out the serial port on startup.

i. Serial Communications

The RM-14SA program reports the current settings and status of the unit whenever the instrument is turned on, via pin 11 (TXD) of A10. Thereafter, the status of the mode and range switches are reported each time the position is changed. If new values for Alarm, Dead Time, or Response Time are defined, the values are reported after the mode is changed and the new value stored.

While in Operate mode, current data are reported every 256 timer interrupts. All messages are sent in ASCII format out the serial port at 9600 b/s, 8 data bits, no parity, and 1 stop bit.

During serial communications operations, the timer value is loaded with a value that provides for transmission at 9600 b/s. The detector pulse counter is not stopped during transmission and, after transmission ends, the count duration is adjusted accordingly.

j. Average Count Rate Determinations

The meter always displays the net count rate, i.e., the gross count rate (corrected for dead time losses) less the count rate stored as the background value. If background subtraction is not used, the stored background should be set to the default value of zero so that the net count rate is equal to the gross count rate. The RM-14SA calculates the average count displayed on the meter using an algorithm which emulates the response of analog type instruments. It incorporates a weighted average with the weighting factor calculated such that the resulting time behavior of the expression exactly tracks that of an analog ratemeter circuit with a response time based on an RC time constant.

$$R_{new} = \frac{R_c + wR_{old}}{w + 1}$$

where:

R_{new} = The new average count rate
R_c = The count rate averaged over the current count interval

R_{old} = The average count rate from the previous calculation

w = The weighting factor

The weighting factor is calculated as:

$$w = \frac{1}{2^p - 1}$$

where:

$$p = 3.32 \frac{t_c}{t_r}$$

t_c = The current counting interval in seconds (depends on range setting)

= 0.0960 on 10 range

= 0.0600 on X100 range

= 0.0750 on X1K range

= 0.0938 on X10K range

= 0.0586 on X100K range

= 0.0732 on X1M range

t_r = the Response Time in seconds

Response Time is defined as the time it takes the meter reading (R_{new}) to go from 0 to 90% o the final value of a step change in the input count rate.

SECTION IV
MAINTENANCE

WARNING

The high voltage power supply is capable of producing over 2500 volts and the energy stored in the filter capacitors may produce a hazardous shock. Voltage bleeds down slowly when the instrument is turned off.

WARNING

Whenever the instrument is switched Off, power is removed from only a portion of the circuit. To completely remove all power sources, the AC power cord must be unplugged and the battery disconnected by removing the battery fuse.

CAUTION

The circuitry in the RM-14SA employs CMOS technology and is subject to damage from electrostatic discharge with the front panel removed. All equipment and components must be grounded to the RM-14SA chassis or circuit common before touching any components.

A. DISASSEMBLY

Maintenance and calibration simplicity has been built into the RM-14SA. The front panel can be removed by pulling off the three "press on" control knobs and removing the four mounting screws. This provides convenient access to the component side of the main circuit board. Calibration, troubleshooting and repair are much easier to accomplish since the internal circuit board doesn't have to be removed in order to access test points or replace components. If access to the power supply or high voltage circuitry is necessary, the PS/HV board may be accessed by removing the rear panel.

B. PREVENTIVE MAINTENANCE

The RM-14SA should be kept as clean and dry as possible. The battery should be replaced after approximately four years of use (a date code is usually present on the bottom face of the battery.) No other routine maintenance is required except for normal (owner specified) periodic recalibration.

CAUTION

Many of Eberline's instruments contain alkaline, carbon, lead, nickel-cadmium or lithium batteries. All batteries contain small amounts of heavy metals and other hazardous materials and must be handled and disposed of properly. Lithium batteries present the following hazards; fire, explosion or severe burn risk. Do not expose the cell contents to water. Recharge only batteries specifically designated as rechargeable and follow the manufacturers recommendations on recharging. Do not puncture, mutilate, or attempt to disassemble, incinerate, or heat above 100°C (212°F). Eberline recommends that all batteries be recycled at appropriate licensed recycling centers or disposed of as required by local ordinances and regulations.

C. CALIBRATION AIDS

The RM-14SA has a built in pulser circuit which can, in many cases, eliminate the need for an external pulser. The pulser provides a 10 mV (±10%) pulse height at three fixed frequencies. The RM-14SA also has an internal connector which provides a serial communications output port. This port (J3 on main board) can be connected to a printer, display terminal, or computer through an optional RS-232 converter and will provide status, setup information, and data in ASCII format. Status and setup information is transmitted at power up and any time a parameter or condition changes. This is very useful during checkout and calibration as various controls and switches can be tested with the result displayed or printed by the connected device. Count rate data is transmitted at an approximate rate of once every 15 seconds. This can be used to minimize calibration errors due to meter interpretation and to automate calibration.

D. GENERAL CALIBRATION

1. Battery Charge Regulator

WARNING

> Use caution when working on the RM-14SA with the rear panel removed. AC voltages of 115 VAC (or 230 VAC) are present.

Remove the rear panel and connect an accurate voltmeter across the battery terminals. Adjust the charge level potentiometer (R19) for a reading of 6.70 to 6.80 volts on the meter. Perform this calibration with the instrument turned On, a fully-charged battery connected, and AC line power present. Replace the rear panel.

2. Meter

WARNING

> Meter calibration will cause instrument calibration parameters and DIP switch presets to be lost when the Default switch is closed.

Turn the instrument Off and with the front panel removed, adjust the mechanical meter zero until the meter reads zero. Verify that JP2 jumper is in position 2 for a counts per minute meterface or position 1 for the optional counts per second meterface. Set the Defaults switch (SW3) to Closed and turn the unit On (the meter should read in the upper half of the scale). Adjust the Meter potentiometer (R47) for a reading of 4.00 on the counts per minute scale, 8.00 on the optional counts per second scale.

3. High Voltage Display

Complete the standard meter calibration described in step 2 before performing high voltage display calibration. For this operation, use a very high impedance voltmeter (1000 Megohms or more). Disconnect the detector and measure the high voltage on the center conductor of the MHV connector. Adjust the high voltage level (R14) for a reading of 2000 volts on the voltmeter. Set the mode switch to High Voltage and adjust the Comp potentiometer (R68) until the RM-14SA meter shows the correct reading of 2000 volts. Adjust the high voltage to a few other values across the meter face and compare the RM-14SA reading to the external voltmeter. The agreement should be within 50 volts plus any inaccuracy of the external voltmeter.

If only one detector at one high voltage setting is to be used, a more accurate high voltage readout may be obtained. Measuring with the external meter, adjust (R14) for the high voltage output required by the detector. Then adjust the Comp potentiometer (R68) until the RM-14SA meter reading matches the external meter reading. Note that the accuracy of the RM-14SA high voltage readout at other high voltage settings will not be as accurate as the HV setting for this particular detector.

WARNING

> Be sure to restore DIP switch presets for Dead Time and Alarm Setpoint adjustment control (SW1 & SW2) and for background update switch polarity (SW4), before proceeding. (See Section II Operation, C. Internal Controls for further information).

E. CALIBRATION WITH A DETECTOR

1. General

The RM-14SA is an extremely versatile instrument that can be used with a wide variety of detectors. The purpose of instrument calibration is to produce readings which accurately reflect the detected count rate.

Properly set up and calibrated, the instrument is inherently linear and accurate, a result of its microcomputer-based design. Usefulness of the instrument is only limited by the practicality of the detector for a specific application. For detector application information, see Table 7-1.

2. Input Sensitivity

Table 7-1 lists several Eberline detector models and gives typical calibration settings for each. Unless the application requires PHA, the input sensitivity can be set as shown since the sensitivity is not critical for gross counting mode. For detectors not listed, set the sensitivity to 10 mV.

For a fixed sensitivity of 10 mV, the internal RM-14SA pulser signal may be used to calibrate the threshold. Connect a jumper between test points TP4A and TP4B and adjust the Thld level.

For all sensitivities between 5 and 15 mV, set the Gain control fully clockwise for maximum gain. Connect a calibrated pulse generator (Eberline minipulser Model MP-1 or MP-2, typical) to the detector connector and set the input sensitivity by adjusting the Thld control.

If the input sensitivity is to be set at more than 15 mV (up to 50 mV maximum), a calibrated pulse generator (Eberline minipulser) or pulser and oscilloscope will be required. Connect the pulse generator to the detector connector and set the signal (negative) amplitude to the desired sensitivity level. Set the Thld control fully clockwise, then adjust the Gain control until the crossover point is located.

3. High Voltage Setting

WARNING

> To prevent damage to the detector, the high voltage setting should be set to the nominal operating voltage or less (Ref. Section VII) before connecting the detector to the RM-14SA. Check the setting by selecting the High Voltage mode. (Make sure that calibration of the high voltage reading has been performed).

The bias (high voltage) operating point for a GM detector is fixed by it physical properties (i.e., size, counting gas, anode size, and fill pressure). Therefore, a check of its sensitivity, or efficiency, may preclude the plateau. It should be within ±20% of specified sensitivity at the specified operating voltage (see Table 7-1).

To run a plateau, connect the detector to the RM-14SA with the cable to be used in operation. With the discriminator properly set, the plateau curve can be plotted. See Figure 4-1.

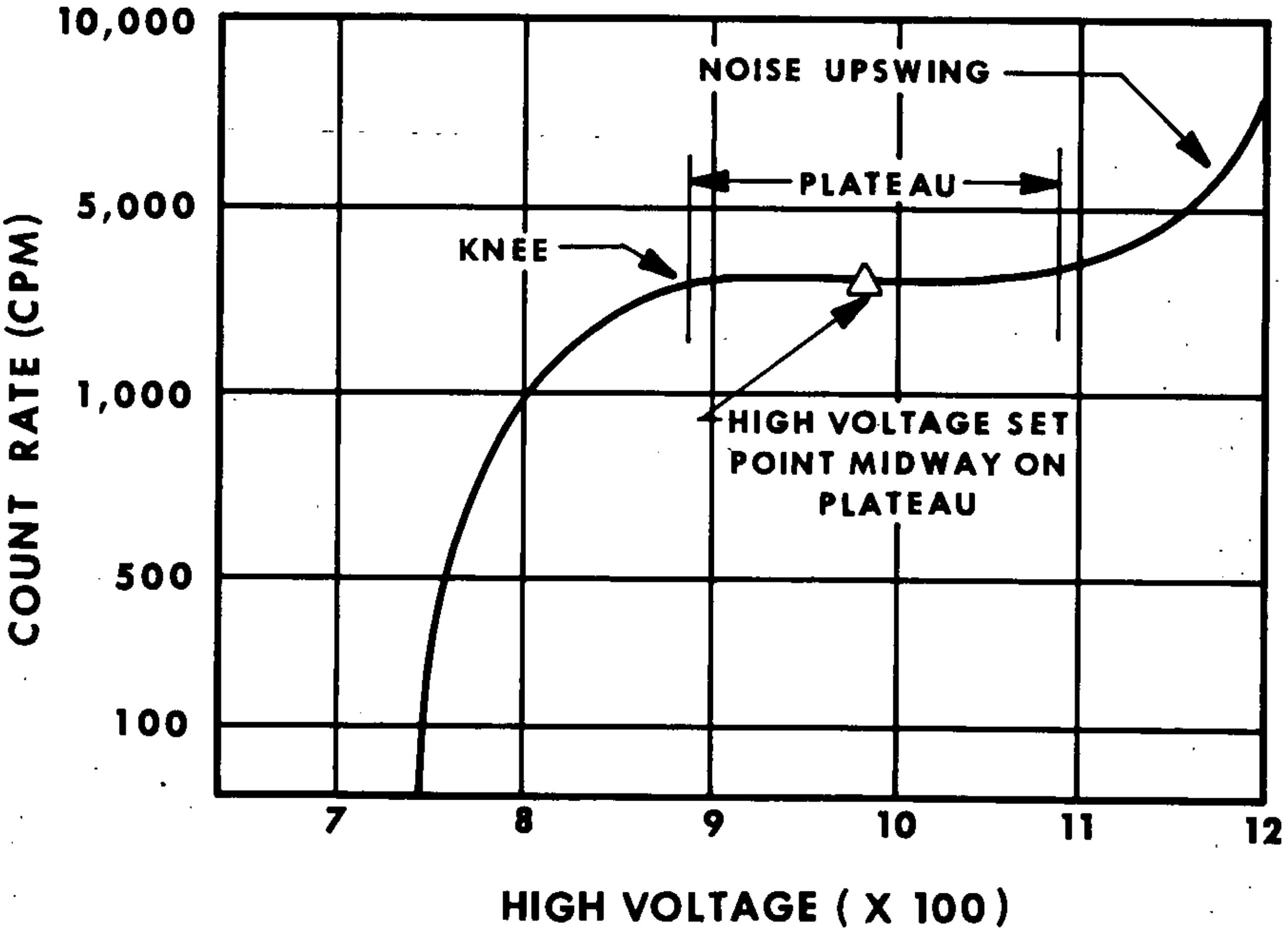


Figure 4-1, Typical Plateau Curve (11338-B25)

To plot a plateau select a Response Time of about 10 seconds. Expose the detector to the source of radiation. The exposure rate should be sufficient to provide an upscale reading. Select the High Voltage mode and set the HV Adjustment (R14) for a low reading.

Select Operate mode again and set the range switch to the appropriate range and record the meter reading. Change to High Voltage mode again and increase the high voltage in 50- to 100-volt steps, recording the reading at each point. Allow enough time at each step for the reading to stabilize. Plot the plateau curve and set the high voltage accordingly.

An alternate, less formal method of determining the plateau location, consists of the following. Connect the detector and expose it to the radiation source. Set the range switch to an appropriate multiplier position and slowly bring the high voltage up until a plateau region is found. Adjust the high voltage until the low end of the plateau is found. Switch to the High Voltage position and record the high voltage. Switch back to the multiplier position and carefully bring up the high voltage until the upper end of the plateau is found. Compare the two high voltage values and select an operating point in between.

4. Calibration Procedure for any Detector

a. Determine the detector sensitivity in cpm per rate unit (e.g. cpm/mR/h). Set the Response Time to 20 seconds and place the detector in the recommended sensitivity calibration field noted in Table 7-1. After approximately 50 seconds, the reading should have stabilized. Divide the reading by the field strength. The result is the detector sensitivity, which should be approximately equal to the value found in Table 7-1 for the same type detector.

b. Set the Response Time back to 5 seconds and expose the detector to a relatively high field where the dead time losses are significant. (Table 7-1 gives recommended dead time calibration fields for some standard Eberline detectors.) Based on the detector sensitivity determined in 4.a, calculate the expected count rate for the new field. Adjust the Dead Time so that the meter reads the expected count rate when the probe is placed in the new field.

NOTE

Before determining sensitivity, preset the Dead Time to the nominal value in Table 7-1.

NOTE

Dead Time may be set to zero, or from 5 to 255 microseconds. All Dead Time values less than 5 microseconds will be set to zero, disabling dead time correction.

c. Perform a linearity check at various exposure rates from a low rate up to where the overrange alarm is given. Overrange occurs at a precomputed count rate, based on the Dead Time setting. The RM-14SA must be turned Off, the count rate reduced, and turned back On to reset the overrange alarm. If desired, adjust the Dead Time value slightly to average out points where the meter reading is above and below the nominal value.

d. If radiation fields high enough to cause sufficient dead time losses are not available, set the Dead Time to the nominal value given for the detector in Table 7-1.

e. Calibration Summary

1) Set the input sensitivity with the Thld and Gain controls.

2) Set the high voltage with the HV control.

3) Determine detector sensitivity at a low count rate.

4) Determine the dead time at a high count rate.

5) Perform linearity checks.

5. Calibration with PHA

To utilize the pulse-height analyzer (PHA) function, the amplitude of the detector pulses must be proportional to the energy of the radiation and must vary with the high voltage applied to the detector.

A review of the PHA circuit description and terms used in the "Operational Theory" section may be helpful. The adjustment of the window width, relative to the threshold setting, is always a compromise. Refer to Figure 4-2. In each case, the narrower window results in a sharper peak (better exclusion of adjacent energies), but the count rate is lower and the peak may be harder to find. Experimentation using the particular detector and a check source of the isotope of interest will help select the best percent window for your application. In general, a window between 25 percent and 100 percent of the threshold level is reasonable.

The following are examples of various methods of setting the threshold and window controls.

a. Method 1. No test equipment required.

1) Set the Gain control fully clockwise for maximum gain.

2) Set the Thld control fully clockwise for least sensitivity. This will result in about 6mV input sensitivity.

3) Set the Win control fully clockwise for widest window. This will set the window about 6 mV wide, a 100 percent window. (For a 50 percent window, set the Win control midway between the end points [about 12 turns of the 25 turn pot].)

4) Set the PHA/Gross switch to P (PHA).

5) Expose the detector to the isotope of interest and adjust the high voltage until the energy peak lies in the window, indicated by a decrease in reading when the high voltage is adjusted either way. Remove the source to verify that the proper peak was found.

6) Check the Gross (G) position. The reading will increase if energies above the window setting are present at the detector. Reset switch to PHA (P) operation.

b. Method 2. Voltmeter method.

1) Set the Gain control fully clockwise for maximum gain.

2) Set the Thld control fully clockwise for least sensitivity.

3) Connect the reference lead of a voltmeter to the Ref test point TP3.

4) Measure the voltage at the Thld test point TP2. It will be approximately 1 V with respect to the reference lead.

5) Connect the voltmeter lead to the Win test point TP1. Adjust the Win control for a positive voltage equivalent to the percent window desired. For a 25 percent window, make this voltage one-quarter as large as that found in step 4, and so forth.

6) Set the PHA/Gross switch to PHA (P).

7) Expose the detector to the isotope of interest and adjust the high voltage until the energy peak is in the window. Remove the

source to verify that the proper peak was found.

8) Check the Gross (G) switch position where the reading will increase if energies above the window setting are present at the detector. Return to (P) for PHA operation.

c. Method 3. Pulser Usage

A calibrated pulser could have taken the place of the voltmeter in method 2 (immediately preceding). Instead of measuring the threshold and window voltages, the pulser, connected to the detector connector, could have been used to establish the desired signal levels and the Thld and Win control adjusted for crossover. The window would then have been at 50 percent (threshold 6, window width 3).

This next procedure uses the pulser to set up the PHA circuit to correspond to actual energy levels. Once set, a voltmeter can be used to select a different specific energy.

1) Connect the calibrated pulser (Eberline Minipulser, for example) to the detector connector.

2) Set the pulser for 10 mV output, between 2k to 20k cpm.

3) Set the PHA/Gross switch to G (gross).

4) Set the Thld control fully clockwise for minimum sensitivity.

5) Adjust the Gain control until the crossover point is located.

6) Set the PHA/Gross switch to P (PHA on).

7) Set the pulser for 12 mV.

8) Adjust the Win control until crossover is located.

9) Set the pulser at 5.6 mV output.

10) Set the PHA/Gross switch to G (Gross).

11) Adjust the Thld control until the crossover point is located.

12) Remove the pulser and connect the detector to be used.

13) Set the PHA/Gross switch to P (PHA on).

14) Expose the detector to a ^{137}Cs source and adjust the high voltage until the cesium peak (660 keV) is in the window. Remove the source to help make sure the proper peak was found.

As now set up, the nominal span of the threshold and window controls is from zero to 1 MeV, corresponding to zero to one volt as measured on the Thld and Win test points TP2 and TP1, referenced to TP3. (For measurement points, see method 2 above.) A voltmeter can now be used to set new specific energies for the threshold and window widths. Remember, the peak is centered in the window, which is one-half a window width above the threshold setting.

If, in step 9 the pulser had been set at 2.3 mV instead of 5.6 mV, the nominal calibration would have been from zero to 2 MeV. An alternate method to obtain zero to 2 MeV is to use ^{60}Co (1.25 MeV, average of two peaks) instead of ^{137}Cs and set the pulser at 5.25 mV in step 9.

In all cases, where possible, the isotope of interest should be used to make the final adjustment to make sure the energy peaked in the window.

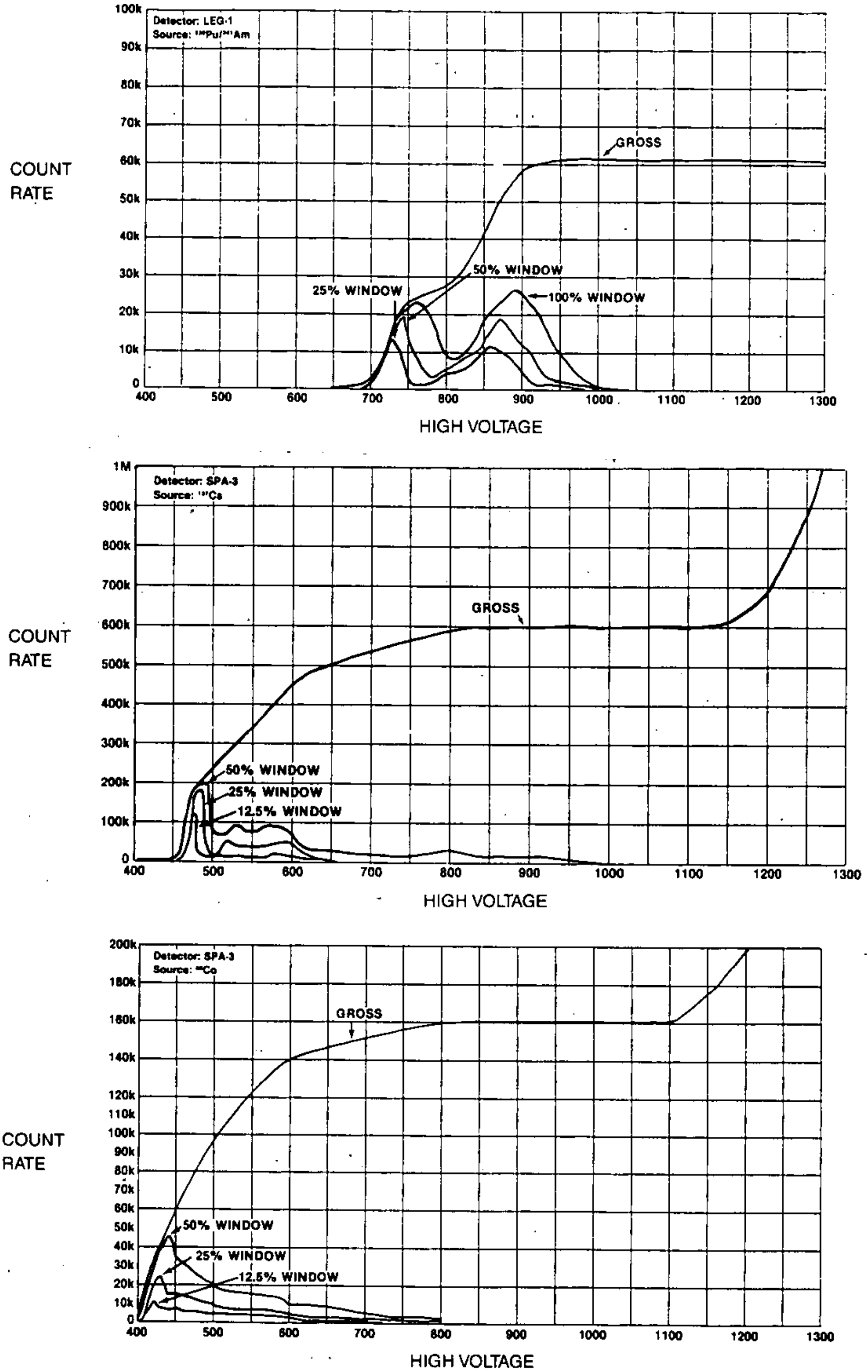


Figure 4-2. Typical PHA Operating Curves

F. TROUBLESHOOTING

The primary troubleshooting aid is a thorough understanding of the circuit functions. Section III, Operational Theory, and Figure 6-2, the schematic, are the primary aids to this understanding.

The following table provides some possible solutions to specific symptoms.

NO.	SYMPTOM	POSSIBLE FAULT	POSSIBLE SOLUTIONS
1.	LED's come on but instrument will not respond to controls	Processor inoperative Defaults switch is set Switched +5 regulator bad	Check oscillator X1, A6 Open SW3 Replace A16
2.	Instrument totally dead, +V1 line is low	+5V regulator is bad No AC line or battery source Heavy load on +V1 line	Replace A13 Check fuses Replace faulty component
3.	Operates on battery only	Bad power supply component Isolation diode is bad	Replace faulty component Replace CR12
4.	No high voltage, or HV ADJ pot has no control over HV	Bad HV oscillator Bad tripler diode Heavy load on HV.	Replace Q2, T1 Replace CR1, CR2, or CR3 Check detector and detector cable
5.	High voltage output unstable.	High voltage leakage or component breakdown	Check detector and detector cable. Clean HV components and circuit board Clean MHV connector Replace faulty component
6.	Meter does not display high voltage correctly	Meter not calibrated for HV	Perform high voltage calibration procedure
7.	Meter displays count rate but no audible count rate indication	Bad speaker oscillator Bad speaker drive component Bad speaker	Replace A8 Check Q6 and Q8 Replace speaker
8.	Audible count rate but meter displays zero	Bad divide-by-2 flip-flop Background subtraction enabled (Reset LED blinks approx. every 5 sec.) Incorrect range setting	Replace A5 Check SW4 Restore defaults and recalibrate to disable background subtraction Drop to lower range switch position
9.	Battery level reads low on meter when instrument is line powered	Charge level is incorrect Slo-Blo type fuse is being used	Set battery charge level at 6.75 V Use non-resistive fuse
10.	Battery level reads low when running off battery	Slo-Blo type fuse is being used Bad or old battery (more than 4 years)	Use non-resistive fuse Replace battery

Table 4-1, Troubleshooting Guide

NO.	SYMPTOM	POSSIBLE FAULT	POSSIBLE SOLUTIONS
11.	Instrument operates but will not turn off	Bad power-down circuit component Bad On/Off switch Q5 shorted	Replace A14 Replace SW5 Replace Q5
12.	Meter reads zero in all modes	Bad D/A meter driver Meter miscalibrated Bad meter or meter connection	Replace A7 Check meter calibration Check meter terminals Replace meter
13.	Meter reads 4.00 or upscale in all modes	Defaults switch (SW3) is set	Open switch (SW3)
14.	Can read but cannot set parameters	Front panel Lockout switch (SW1) set	Open switch (SW1)
15.	Instrument beeps continuously when turned On, will not operate	Bad Reset switch	Replace SW6
16.	Instrument will not count high voltage okay, +V1 and +V2 okay	Bad amplifier component Bad detector Open detector cable PHA switch (SW9) is set and discriminator window is too narrow Bad discriminator component	Check for signal at TP2. If no signal, check Gain adjust and/or replace A2 or Q3. Replace detector Replace cable Check SW9, Recalibrate PHA Replace A2 - A4
17.	Instrument does not operate and will not turn off. LED's stay lit.	Processor is "hung up"	Unplug AC and remove battery fuse to remove processor power, then restore power and parameters

Table 4-1, Troubleshooting Guide (continued)

SECTION V
PARTS LIST

The following table lists the electronic items incorporated in the RM-14SA and should contain any part necessary for normal repair. Unless otherwise specified, callouts of manufacturers or manufacturers' part numbers are to be considered typical examples only and not restrictions against using equivalent parts with the same operating characteristics. When ordering parts from Eberline, specify model number, serial number, reference designator, value, Eberline part number, or a word description if the part has no reference designation. Eberline will automatically substitute equivalent parts when one called out by the manufacturers' part number is not available.

REF DESIG	PART	DESCRIPTION	MANUFACTURER AND PART NUMBER	EBERLINE PART NUMBER
1. Basic RM-14SA				
	Battery	6V Gel-Cel	Globe GC-610-1B	BTGC2(3)
	Fuse Drawer	AC Fuse Drawer	Corcom SC1N	COHD73(2)
	Receptacle	Int'l. Style AC Recept.	Corcom 16ESC1D1	COPR13(9)
	Fuse Holder	Battery Fuse Holder	Bussman HTB-32I	FUHO7(6)
	Fuse	1/4 Amp, 250V Type 3AG	Littlefuse 312.250	FUST8(5)
	Handle	Black Aluminum	Vemaline EF610	HDHA9(6)
	Bail	5 1/2" x 2" Bail w/Feet	Buckeye MP41226-20	HDIS1(8)
	Knob	Push-On with Pointer	Rogan G-100-P	HDKN26(1)
	Manual	RM-14SA Technical Manual		MA-RM14SA(5)
	Screw	Custom Black Phillips		SCFH0406PB(0)
	Screwdriver	High Voltage Screwdriver		VEMI68(4)
	Powercord	Int'l. Style AC Powercord	Belden 17250	WRAC4(4)
2. Main P.C. Board, Part No. YP11529003(1)				
JP2X	Jumper	2-Circuit Jumper		COMR1302(4)
JP2	Header	3-Pin Male Conn.		COMR1303(3)
C22	Capacitor	100 pF-50V	AVX SR151A101KAA	CPCE101P3N(3)

REF DESIG	PART	DESCRIPTION	MANUFACTURER AND PART NUMBER	EBERLINE PART NUMBER
C24	Capacitor	1000 pF-100V, 10%	Centralab CN20A102K	CPCE102P3P(9)
C14	Capacitor	0.01 µF, 50V	Kemet C321C103M5U5CA	CPCE103P4N(7)
C2, C4, C5, C7, C9, C10, C12, C13, C16, C19, C20, C23, C25, C26	Capacitor	0.1 µF, 50V, 10%	Centralab CW20C104K	CPCE104P3N(7)
C1, C8	Capacitor	220 pF, 3000V, 10%	Centralab DD30-221	CPCE221P3Y(5)
C27, C28	Capacitor	33 pF, 100V, 10% or 20%	Erie CK12BX330K	CPCE330P3P(6)
C21	Capacitor	.022 µF, 100V, 10%	Erie CK06BX223K	CPCE223P3P(3)
C11	Capacitor	10 µF, 16V, 20%	Sprague 199D106X0016CB1	CPTA100M4X(3)
C6, C17	Capacitor	39 µF, 10V, 10% Tantalum	Sprague 199D396X9010DA1	CPTA390M3F(5)
C3, C15, C18	Capacitor	1.0 µF, 35V, 10% Tantalum	Sprague 199D105X9035AA1	CPXX11(9)
CR1, CR3, CR5	Diode	Silicon, Switching	1N4148	CRSI1N4148(7)
CR4	Diode	Diode, Schottky	1N5711	CRSI1N5711(1)
J1	Connector	PC Mount, MHV	Amphenol 27000	CXMH10(9)
X1	Crystal	7.3728 MHz, 0.003%	Statek CX-1V-A	CYOS12(5)
A2	Integrated Circuit	Dual Op-Amp, Dual Comp.	Motorola MC14575P	ICAOA14575(5)
A7	Integrated Circuit	D/A Converter, 8-bit	Analog Devices AD7524JN	ICCMA07524(9)
A1	Integrated Circuit	Dual Op-Amp, Dual Comp.		ICXX14575(9)
A8, A9	Integrated Circuit	Quad 2-input NOR Gate	RCA CD4001BE	ICCMA4001B(8)

REF DESIG	PART	DESCRIPTION	MANUFACTURER AND PART NUMBER	EBERLINE PART NUMBER
A4	Integrated Circuit	Quad 2-input NAND Gate	RCA CF74HC00E	ICHCA00(8)
A3, A5	Integrated Circuit	Dual D Flip-Flop	RCA CD74HC74E	ICHCA74(3)
A6	Integrated Circuit	Quad Open-Collector Driver	Sprague UCN-5800A	ICXXA5800A(6)
A10	Integrated Circuit	Microcomputer, Mask ROM		ICXXRM14SA(7)
TP1, 2, 3, 4	Test Point	Lerco Lug	Lerco 5020-D1	ITLG4(7)
M1	Meter	200 microamp - CPM Meter Face	Modutec	MTPA38(7)
M1	Meter (optional)	200 microamp - CPS Meter Face	Modutec	MTPA34(1)
CR2	LED	High Intensity Red	H/P 5082-4655	OPLP10(3)
R37	Potentiometer	10k ohm, 1/2W, 20%	CTS SA1302	PTCC103B63(6)
R18, R19	Potentiometer	10k ohm, 1/4W, 10%	Bourns 3299W-1-103	PTCE103B33(1)
R25	Potentiometer	100k ohm, 1/4W, 10%	Bourns 3299W-1-104	PTCE104B03(5)
R47	Potentiometer	500 ohm	3299W-1-501 #	PTCE501B33(6)
R5	Potentiometer	5k ohm, 1/4W, 10%	Bourns 3299W-1-502	PTCE502B33(4)
R12	Potentiometer	50k ohm, 1/4W, 10%	Bourns 3299W-1-503	PTCE503B23(4)
RP1	Resistor Array	10k ohm, 1/4W, 9 w/com.	CTS 750-101-R10K	REAR103B21(0)
R2, R48	Resistor	100 ohm, 1/4W, 5%		RECC101B22(6)
R3, R7	Resistor	10k ohm, 1/4W, 5%		RECC103B22(2)
R1, R15	Resistor	100k ohm, 1/4W, 5%		RECC104B22(0)
R9	Resistor	10 M ohm, 1/4W, 5%		RECC106B22(5)
R34	Resistor	150 ohm, 1/4W, 5%		RECC151B22(1)
R39, R42	Resistor	2k ohm, 1/4W, 5%		RECC202B22(2)
R13, R14	Resistor	20k ohm, 1/4W, 5%		RECC203B22(0)
R35	Resistor	22 ohm, 1/4W, 5%		RECC220B22(4)

REF DESIG	PART	DESCRIPTION	MANUFACTURER AND PART NUMBER	EBERLINE PART NUMBER
R4, R16	Resistor	220 ohm, 1/8W, 5%		RECC221B21(3)
R8	Resistor	240k ohm, 1/8W, 5%		RECC244B21(5)
R46	Resistor	270k ohm, 1/4W, 5%		RECC274B22(1)
R11	Resistor	43k ohm, 1/4W, 5%		RECC433B22(3)
R10	Resistor	430k, 1/4W, 5%		RECC473B22(9)
R45	Resistor	510k, 1/8W, 5%		RECC514B21(1)
R44	Resistor	5.1M ohm, 1/4W, 5%		RECC515B22(7)
R32, R33	Resistor	680 ohm, 1/4W, 5%		RECC681B22(7)
R40	Resistor	750, 1/4W, 5%		RECC751B22(8)
R6	Resistor	5.1k, 1/4W, 5%		RECC512B22(4)
R41	Resistor	75k ohm, 1/4W, 5%		RECC753B22(4)
R17	Resistor	10k ohm, 1/4W, 1%	RN55D	RECE103B12(2)
R23, R31	Resistor	150k ohm, 1/4W, 1%	RN55D	RECE154B12(5)
R20, R24, R26, R30	Resistor	20k ohm, 1/4W, 1%	RN55D	RECE203B12(0)
R28, R29, R36	Resistor	200k ohm, 1/4W, 1%	RN55D	RECE204B12(8)
R21, R27	Resistor	2.1k ohm, 1/4W, 1%	RN55D	RECE212B12(1)
R38	Resistor	249k ohm, 1/4W, 1%	RN55D	RECE244B12(4)
R22	Resistor	68.1k ohm, 1/4W, 1%	RN55D	RECE683B12(3)
SW1-4	Switch	4-Switch DIP Array, SPST	Grayhill 76SB04S	SWMI48(3)
SW5	Pushbutton	Red Cap w/Grn & Yel LED	C&K MP01-52-3-65-C-BE	SWPB23(2)
SW6	Pushbutton	Blk Cap w/Grn LED	C&K MP01-51-2-60-C-BE	SWPB24(1)
SW7, SW8	Rotary Switch	6-position Rotary Switch	C&K R106-07-RN-02-Q-E	SWRO54(5)
SW9	Slide Switch	Miniature Slide, SPDT	Alcoswitch SSA-12	SWSL8(9)
Q4	Transistor	N-channel MOSFET	Siliconix 2N7000	TRMN2N7000(2)

REF DESIG	PART	DESCRIPTION	MANUFACTURER AND PART NUMBER	EBERLINE PART NUMBER
Q2	Transistor	P-channel MOSFET	Siliconix VP0300M	TRMPVP0300(7)
Q3	Transistor	NPN, Silicon	2N4401	TRSN2N4401(6)
Q1	Transistor	NPN, Silicon	2N5088	TRSN2N5088(3)
3. PS/HV P.C. Board, Part No. YP11528003(2)				
SPKR	Speaker	2 inch Dia.	Layfayette S-433	ADSP3(6)
J3, J4	Connector	Terminal strip	Phoenix #1754025	COTB61(5)
C15	Capacitor	1000 µF, 63V, Alum.	Sprague 515D108M063EN6A	CPAL102M4N(7)
C5	Capacitor	0.001 µF, 3000V, 10%	Centralab DD309-102	CPCE102P3Y(7)
C3, C4	Capacitor	0.001 µF, 3000V, 20%	Sprague 306A-S10	CPCE103P4Y(3)
C7, C14, C18	Capacitor	0.1 µF, 50V, 10%	Centralab CW20C104K	CPCE104P3N(7)
C6	Capacitor	0.27 µF, 50V, 20%	Centralab CW30C274K	CPCE274P4N(6)
C12, C16	Capacitor	0.047 µF, 50V, 20%	Sprague 1G25Z5U473M0508	CPCE473P4N(4)
C1	Capacitor	0.022 µF, 80V, 10%	Sprague 192P2239R8	CPPF223P3O(2)
C2	Capacitor	0.047 µF, 3500V, 10%	American Shizuki	CPPF503PXY(9)
C8	Capacitor	0.47 µF, 35V, 10%, Tantalum	Kemet T110A474K035AS	CPTA474P3L(6)
C13, C17	Capacitor	68 MF-15V, 20%	Kemet T368	CPXX15(5)
C10, C11	Capacitor	1.0 µF, 35V 10%, Tantalum	Sprague 199D105X9035AA1	CPXX11(9)
C9	Capacitor	33 µF, 10V, 10%, Tantalum	Sprague 199D336X9010DA1	CPXX12(8)
A3	Rectifier	Bridge Rectifier	Varo VS148	CRARVS0148(7)
CR6, CR7	Diode	Silicon, Power	1N4001	CRSI1N4001(3)
CR4, CR5	Diode	Silicon, Switching	1N4148	CRSI1N4148(7)
CR1,CR2, CR3	Diode	Silicon, 2500V, PIV	Varo VA25	CRSIVA0025(3)
A1	Integrated Circuit	Dual Op-Amp, Dual Comp	Motorola MC14575P	ICAOA14575(5)

REF DESIG	PART	DESCRIPTION	MANUFACTURER AND PART NUMBER	EBERLINE PART NUMBER
A4	Integrated Circuit	Regulator, 6V	Motorola MC7806CT	ICAV7806(4)
A2, A5	Integrated Circuit	Regulator, 5V	National LP2950CZ-5.0	ICAVA2950C(9)
MOV1, MOV2	MOV	Transient Suppressor, 130V	GE V130LA1	MEVE33(0)
R19	Potentiometer	2k ohm, 1/4W, 10%	Bourns 3299W-1-202	PTCE202B33(1)
R12, R15	Resistor	100 ohm, 1/4W, 5%		RECC101B22(6)
R4	Resistor	1k ohm, 1/4W, 5%		RECC102B22(4)
R2, R21	Resistor	10 M ohm, 1/4W, 5%		RECC106B22(5)
R11, R20	Resistor	2k ohm, 1/4W, 5%		RECC202B22(2)
R7, R10, R14	Resistor	20k ohm, 1/4W, 5%		RECC203B22(0)
R3	Resistor	270 ohm, 1/4W, 5%		RECC271B22(7)
R6, R16	Resistor	30k ohm, 1/4W, 5%		RECC303B22(8)
R13	Resistor	33K, 1/4W, 5%		RECC333B22(5)
R8	Resistor	470 ohm, 1/4W, 5%		RECC471B22(3)
R17, R18	Resistor	4.7k ohm, 1/4W, 5%		RECC472B22(1)
R9	Resistor	510k ohm, 1/4W, 5%		RECC514B22(1)
R5	Resistor	62k ohm, 1/4W, 5%		RECC623B22(9)
R1	Resistor Divider	1000M/1M, 1/4W, 10%		REXX22(4)
T1	Transformer	Blocking Oscillator	Microtran M8149	TFHV5(3)
T2	Transformer	Power	Triad FS 10-600	TFPO38(0)
Q1, Q4	Transistor	NPN, Silicon	2N4401	TRSN2N4401(6)
Q2	Transistor	PNP, Silicon	Motorola 2N4234	TRSP2N4234(7)
Q3	Transistor	PNP, Silicon	2N4403	TRSP2N4403(2)
4. RS-232C Interface Board, Part No. YP11404000(9) (Optional)				
A1	Integrated Circuit		Maxim MAX232EPE	ICXXA32EPE(2)
C1, C2, C3, C4, C5	Capacitor	22µF, 15V, 20%	Sprague 196D/T362	CPTA220M4H(0)

REF DESIG	PART	DESCRIPTION	MANUFACTURER AND PART NUMBER	EBERLINE PART NUMBER
R1	Resistor	3k, 1/4W, 5%		RECC302B22(0)
R2	Resistor	5.1k, 1/4W, 5%		RECC512B22(4)

SECTION VI
DIAGRAMS

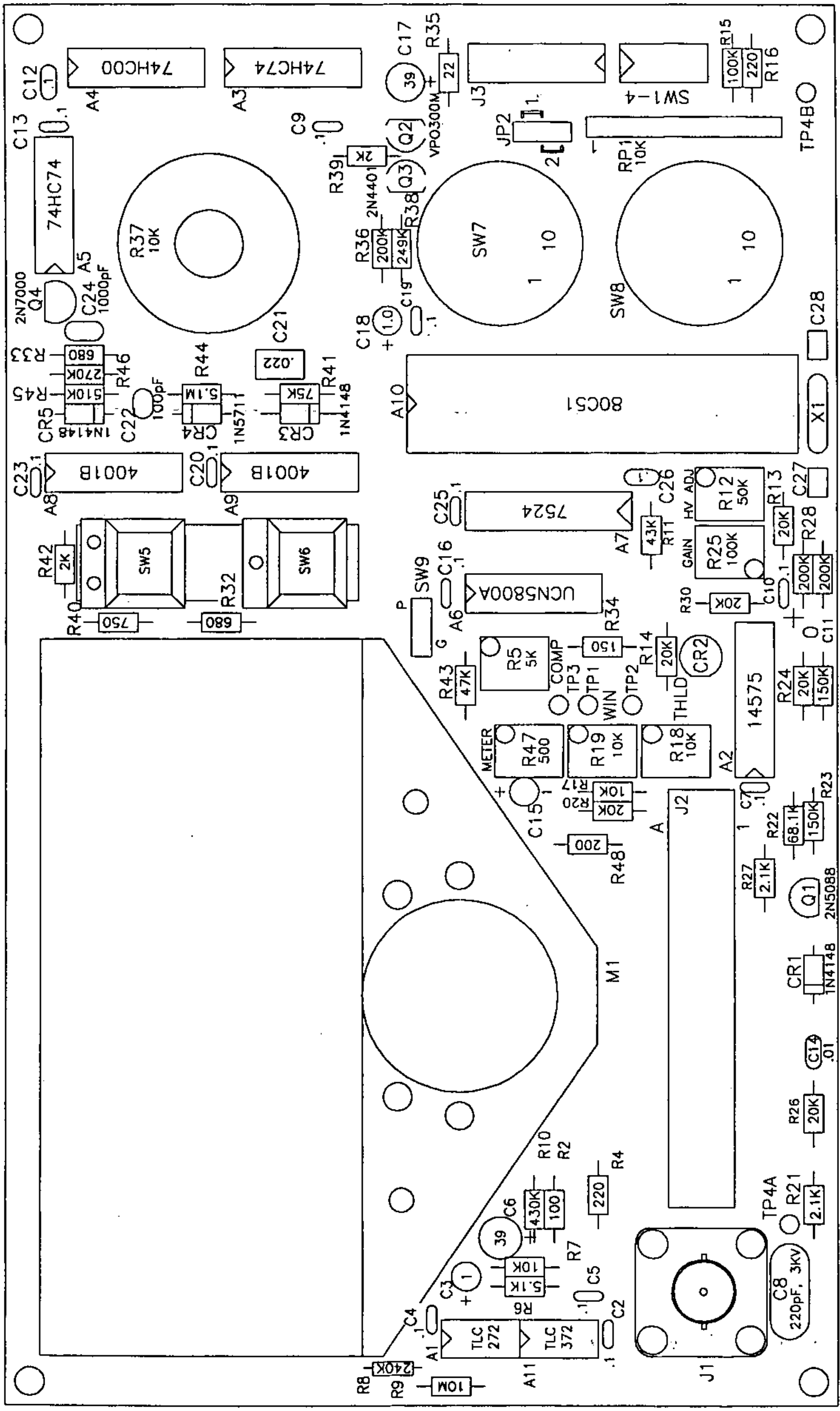
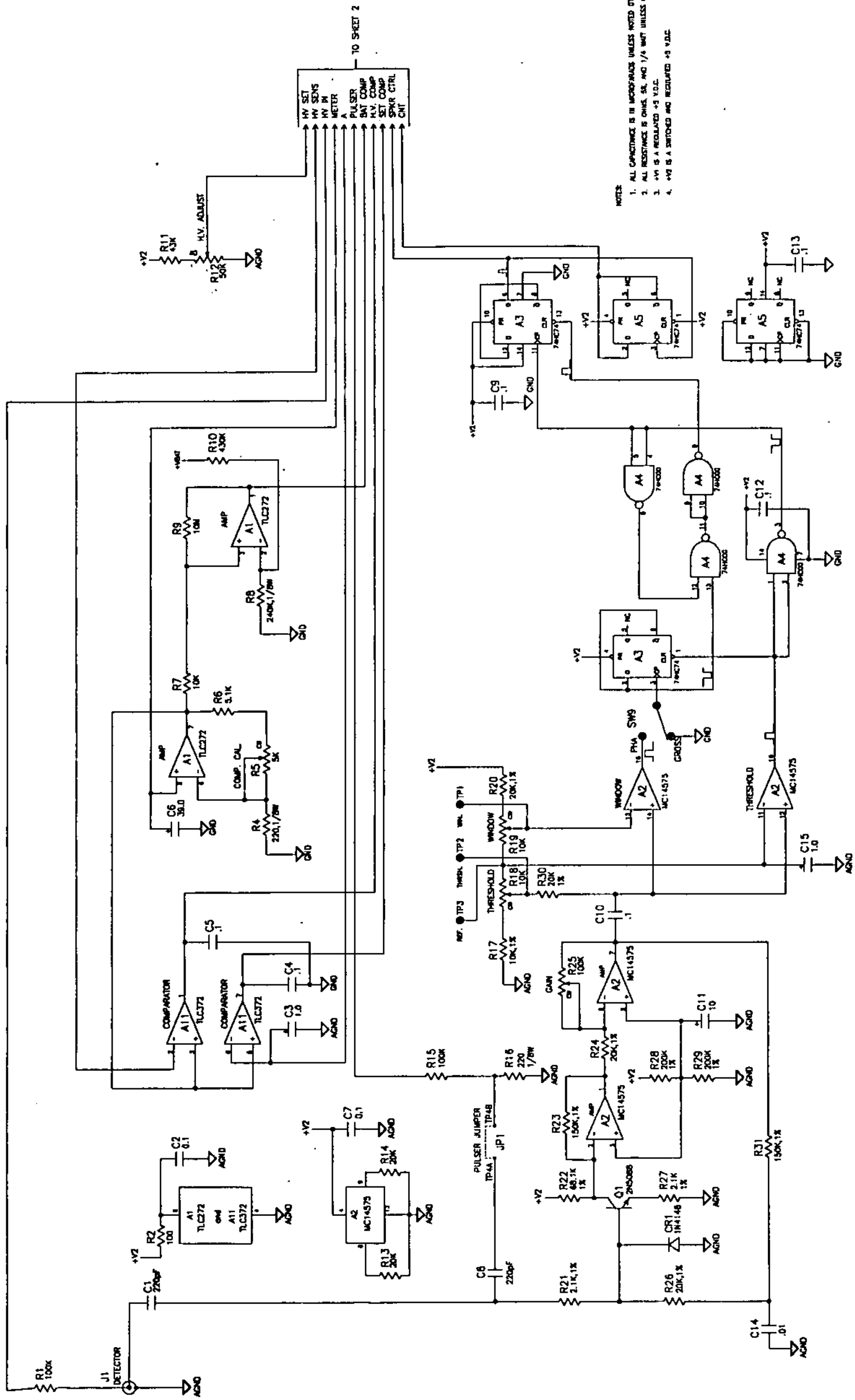


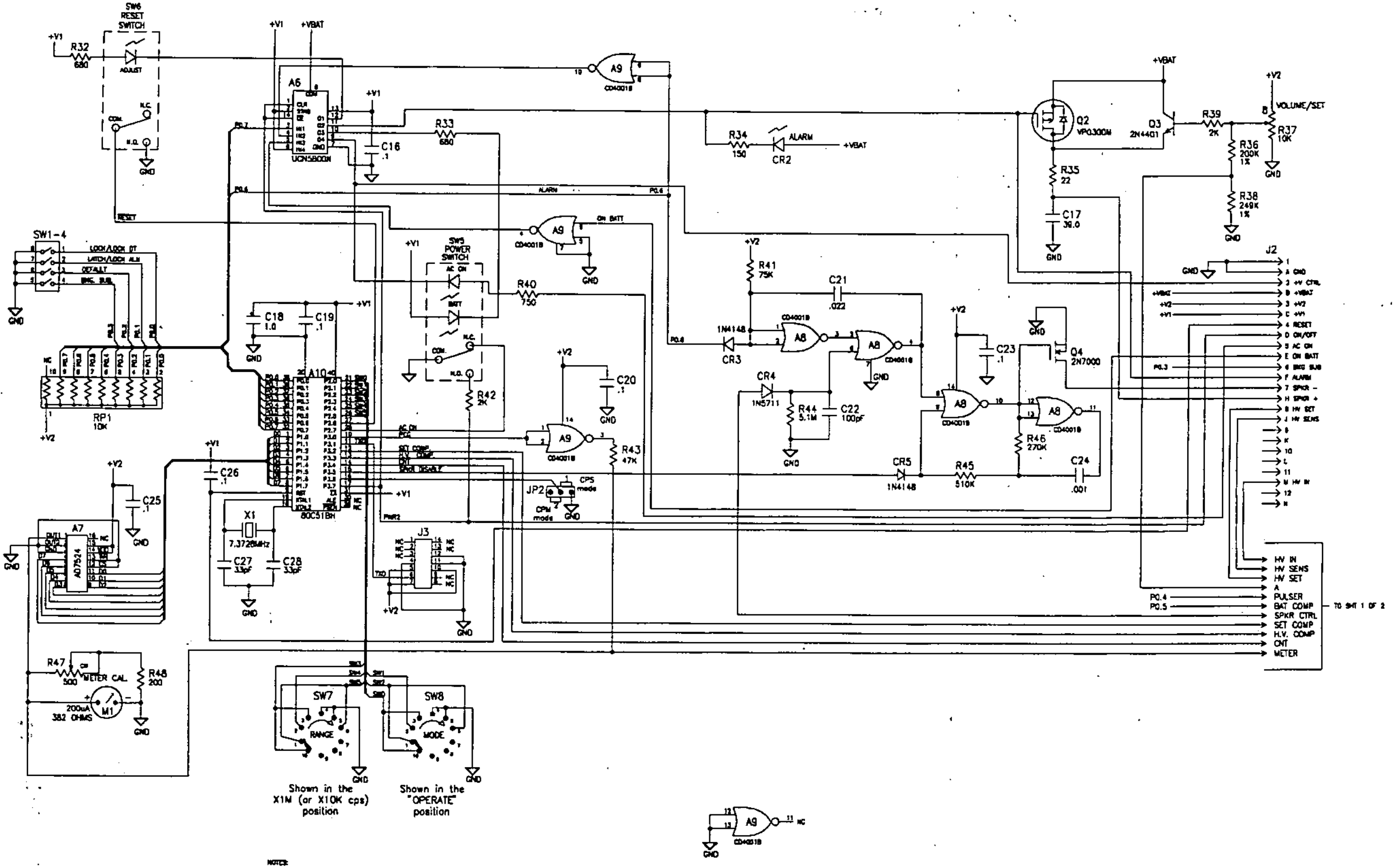
Figure 6-1. Component Layout, RM-14SA Main Circuit Board (11529-D04B)



NOTES:

1. ALL CAPACITANCE IS IN MICROFARADS UNLESS NOTED OTHERWISE.
2. ALL RESISTANCE IS OHMS, 5%, AND 1/4 WATT UNLESS NOTED OTHERWISE.
3. +V1 IS A REGULATED +5 V.D.C.
4. +V2 IS A SWITCHED AND REGULATED +5 V.D.C.

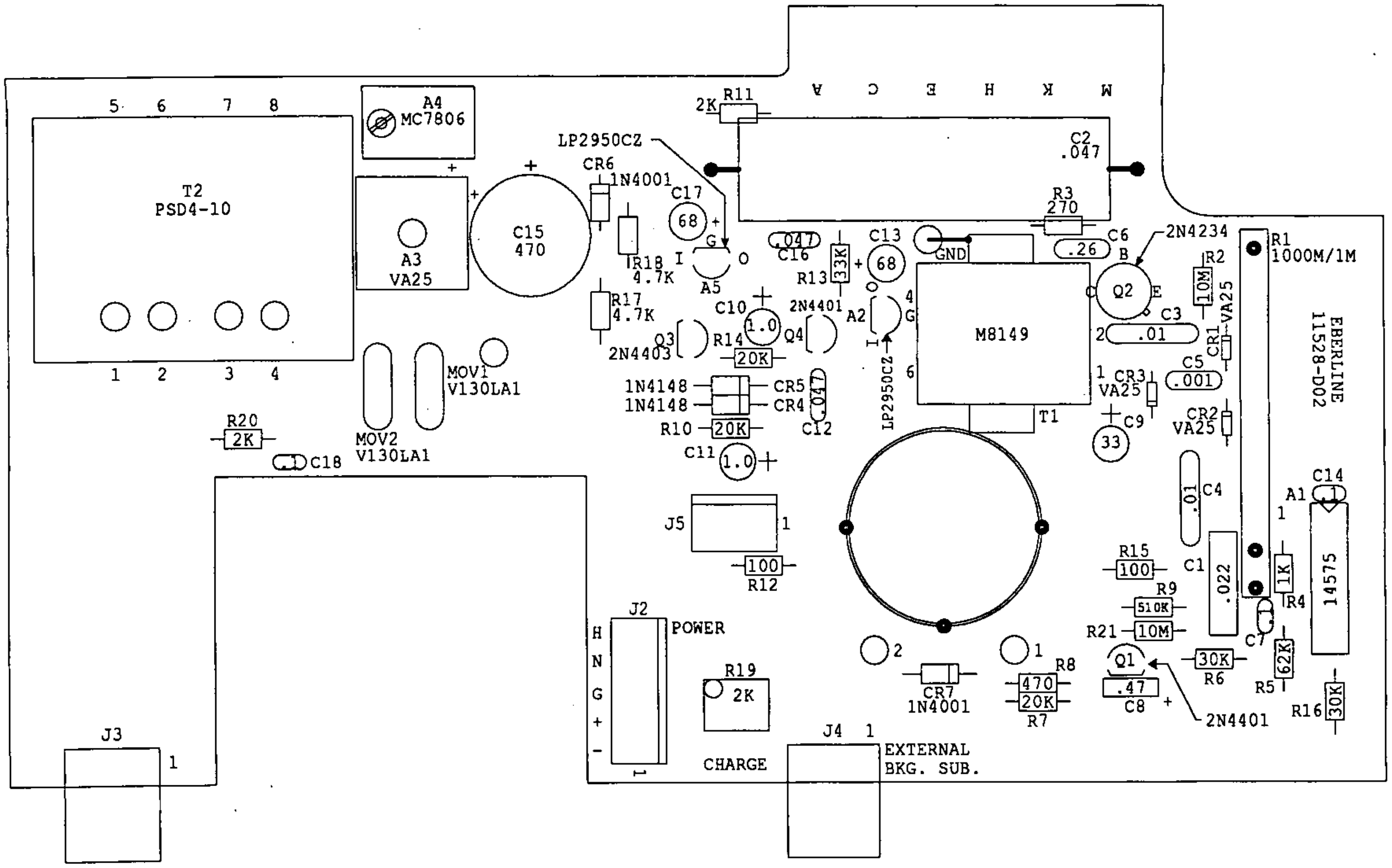
Figure 6-2, RM-14SA Main P.C.B. Schematic (11529-D01C, sheet 1 of 2)



NOTES:

1. ALL CAPACITANCE IS IN MICROFARADS UNLESS NOTED OTHERWISE.
2. ALL RESISTANCE IS OHMS, 5%, AND 1/4 WATT UNLESS NOTED OTHERWISE.
3. +V1 IS A REGULATED +5 V.D.C.
4. +V2 IS A SWITCHED AND REGULATED +5 V.D.C.

Figure 6-2, RM-14SA Main P.C.B. Schematic (11529-D01C, sheet 2 of 2)



NOTES:

1. FOR 230 VOLT OPERATION: FIRST TURN THE P.C.B. OVER. CUT THE TRACE BETWEEN "A" AND "C" AND TRACE "B" AND "D". SOLDER A #20 GAUGE BARE BUS WIRE BETWEEN "B" AND "C".

Figure 6-3, Component Layout, RM-14SA PS/HV Circuit Board (11528-D04)

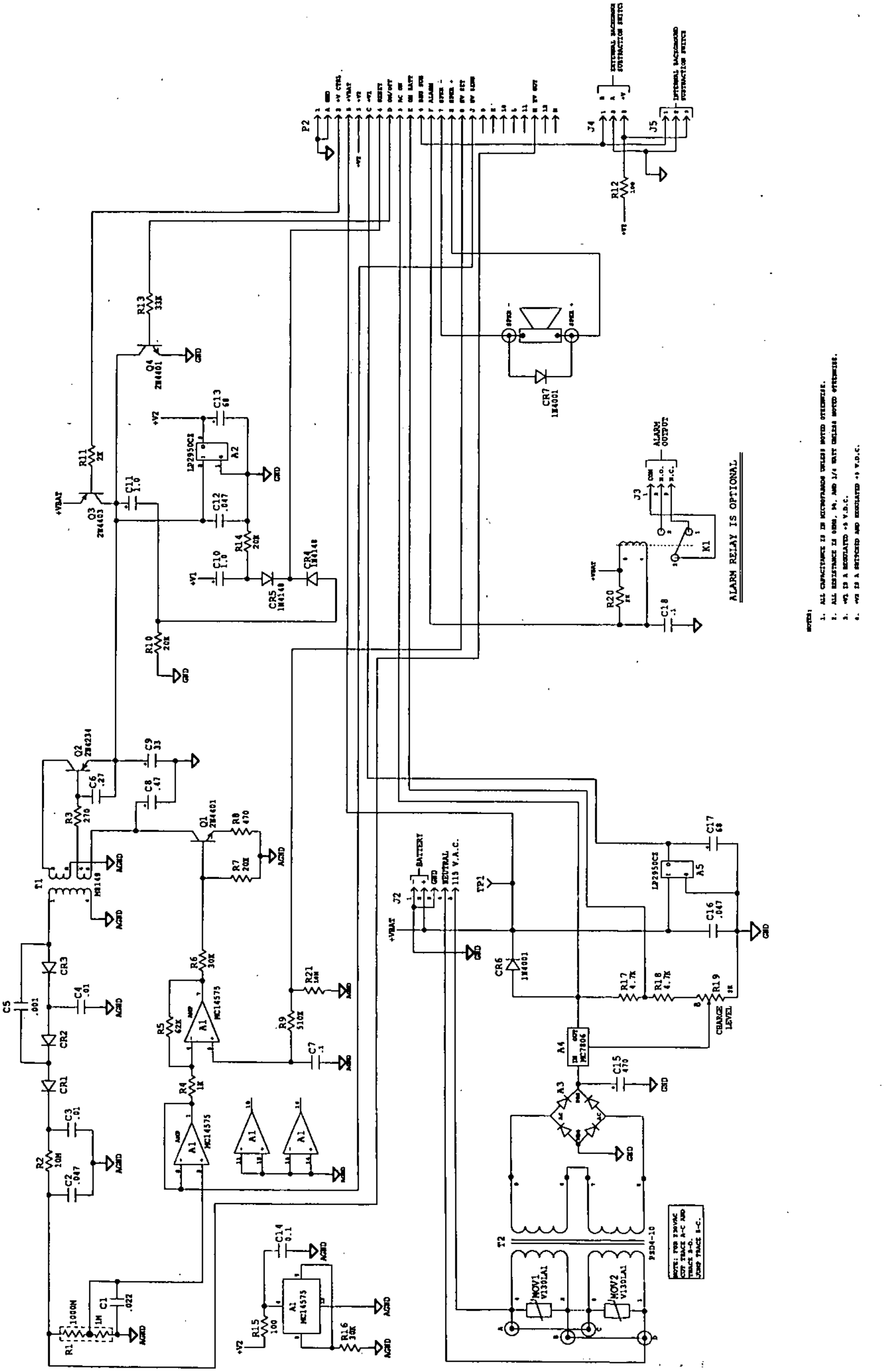


Figure 6-4, RM-14SA PS/HV Board Schematic (11528-D01C)

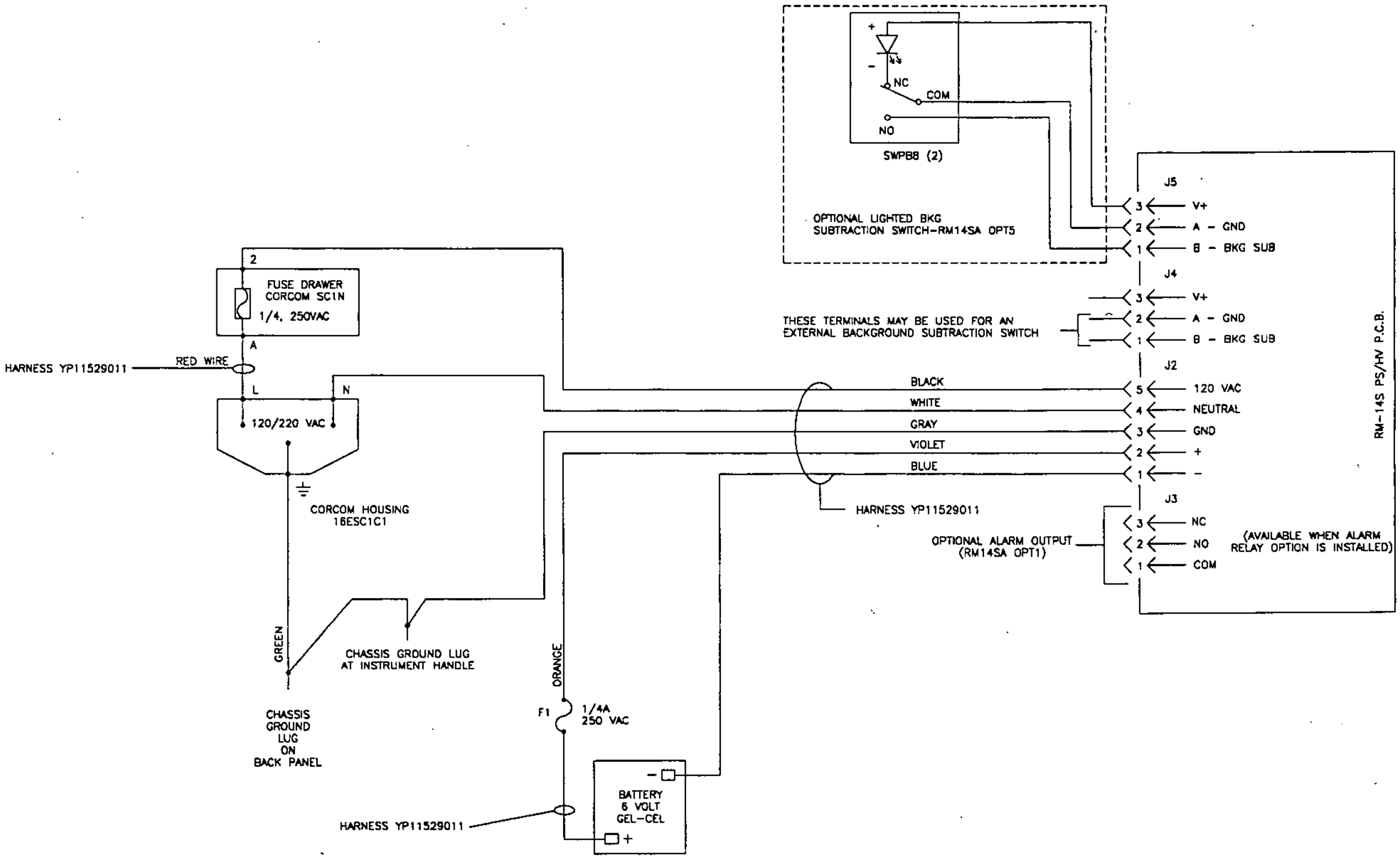

SWPB8 (2)
NC
COM
NO
+
-
OPTIONAL LIGHTED BKG SUBTRACTION SWITCH-RM14SA OPT5
J5
V+
A - GND
B - BKG SUB
J4
V+
A - GND
B - BKG SUB
THESE TERMINALS MAY BE USED FOR AN EXTERNAL BACKGROUND SUBTRACTION SWITCH
J2
120 VAC
NEUTRAL
GND
+
-
J3
NC
NO
COM
RM-14S PS/HV P.C.B.
OPTIONAL ALARM OUTPUT (RM14SA OPT1)
(AVAILABLE WHEN ALARM RELAY OPTION IS INSTALLED)
BLACK
WHITE
GRAY
VIOLET
BLUE
HARNESS YP11529011
FUSE DRAWER CORCOM SC1N 1/4, 250VAC
2
A
RED WIRE
HARNESS YP11529011
L
N
120/220 VAC
CORCOM HOUSING 16ESC1C1
GREEN
CHASSIS GROUND LUG AT INSTRUMENT HANDLE
CHASSIS GROUND LUG ON BACK PANEL
ORANGE
F1
1/4A 250 VAC
BATTERY 6 VOLT GEL-CEL
HARNESS YP11529011

Figure 6-5, RM-14SA Wiring Diagram (11529-C25A)

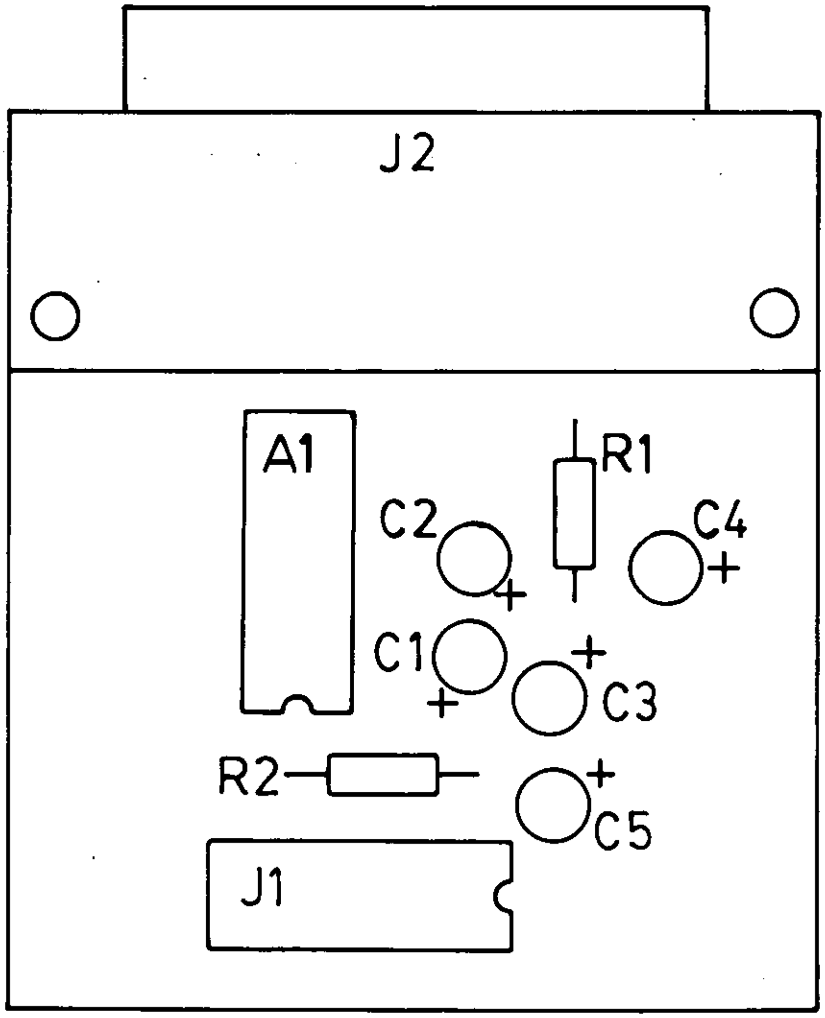
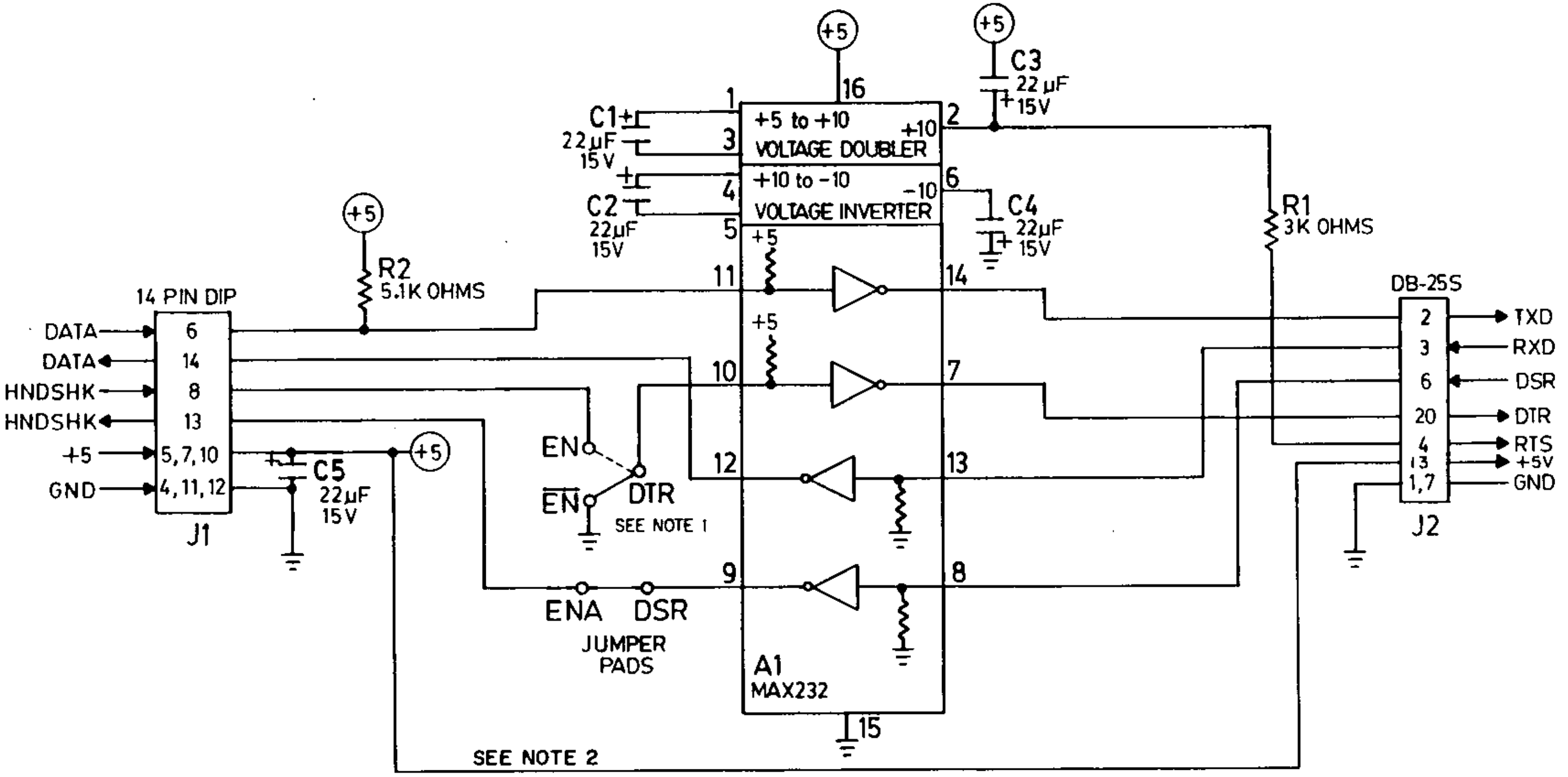


Figure 6-6,. Component Layout, RS-232 Interface (11404-B04)



NOTE:

1. FOR USE WITH PRINTER DTR IS CONNECTED TO $\overline{EN}$ (THIS IS PART NO. YP11404000)
   FOR USE WITH EXTERNAL COMPUTER DTR IS CONNECTED TO EN AS SHOWN
   BY DOTTED LINE AND OTHER CONNECTION IS REMOVED (THIS IS PART NO. SP15A)
2. THIS JUMPER IS ADDED TO SUPPLY AN AUXILARY INPUT DEVICE,
   SUCH AS A BARCODE WAND, WITH A +5V SUPPLY. THIS MODIFICATION
   ONLY APPLIES TO PART NO. YZ11404000.

Figure 6-7, RS-232 Interface Schematic (11404-C02B)

SECTION VII
DETECTORS AND ACCESSORIES

A. OPTIONS

Several options listed below are available on the RM-14SA. Other options may be available on a special request basis (please contact an Eberline sales representative).

1. 230 V Operation

The RM-14SA may be factory modified for 230 Vac operation. The modification may also be performed by the customer (see Schematic).

- Order RM14S OPT4 (3)

2. Alarm Relay Output

Under this option, 2 amp at 120 Vac, normally-open and normally-closed, terminals are provided for wiring to external devices. The relay is activated whenever an alarm occurs, closing the normally-open contacts and opening the normally-closed contacts. The Eberline part number for a replacement relay is RLGP22)(0).

- Order RM14SA OPT1 (6)

3. Set Screw Knobs

This option replaces the standard push-on type front panel knobs with more secure set-screw type knobs for applications where instrument tampering is a problem.

- Order RM14S OPT3 (4)

4. HP-260/270 Probe Holder

This option provides the facility for mounting an Eberline HP-260 or HP-270 probe on the RM-14SA chassis.

- Order YP11448016 (8)

5. HP-210 Probe Holder

This option provides the facility for mounting an Eberline HP-210 probe on the RM-14SA.

- Order YP11448017 (7)

6. HP-100A Probe Holder

This option provides the facility for mounting an Eberline HP-100A probe on the RM-14SA.

- Order YP11448020 (2)

7. RS-232 Test/Calibration Interface

This option includes a cable and interface board for use in performing computer aided test and calibration of an RM-14SA. Since the cable between the RM-14SA and interface board can only be connected with the front panel removed, the customer need not purchase this option for each instrument but may use the same RS-232 test setup for any number of units.

The interface may also be used with a serial printer (see Options 8 and 9 below) as a means of acquiring a printout of test and calibration operations.

The RM-14SA program outputs the current settings and status of the unit whenever the instrument is turned on or a Mode or Range switch position is changed. The output signals are TTL voltage levels sent out through J3 on the Main circuit board. The RS-232 board converts the TTL signals to RS-232 levels.

The conversion between TTL and RS-232 voltage levels is accomplished entirely by a single integrated circuit (IC), the MAX232EPE RS-232 transmitter/receiver. This IC requires a single 5V source and generates its own ±10V as required for RS-232 signal levels.

The printed circuit board is mechanically supported entirely by a standard 25-pin female RS-232 connector. See Section VI-Diagrams for board schematic, layout, etc. and Section V for replacement parts list.

- Order RM14S OPT2 (5)
- Order CA70XXFT (3) cable to PC/AT computer (XX is the cable length, in feet) or use a standard "null modem" cable.

8. Seiko Thermal Printer

The Seiko thermal printer is provided as a standard option with many Eberline instruments and together with the RS-232 Test/Calibration Interface option, provides capability for hardcopy output from an RM-14SA. The printer is small, lightweight, battery or line powered, and supports both 40 and 80 column output modes on 4 1/2 inch paper rolls.

- Order RCDI15 (6) Seiko printer
- Order RCCP16 (8) spare thermal printer paper
- Order CA64XX (2) Seiko printer cable

9. Hewlett/Packard ThinkJet Printer

The ThinkJet serial printer is also offered for use with the RM-14SA and provides the same capability for hard-copy output from the RM-14SA via the RS-2323 Test/Calibration Interface. The H/P ThinkJet is a compact, line powered printer, capable of large volume output.

- Order VEHP55 (3) ThinkJet printer
- Order VEHP28 (7) spare ink cartridge
- Order VEHP29 (6) spare paper (2500 sheets/box) or VEHP30 (3) 1000 sheets/box)
- Order CA57XXFT (0) ThinkJet printer cable.

10. Lighted Background Subtraction Switch

This option provides a lighted pushbutton switch on top of the instrument for ease of performing background updates. When lit, the switch indicates the background subtraction value is being subtracted to provide net count rates. This switch does not replace the internal background subtract switch, but merely supplements its' function for more convenient (though less secure) operation.

In normal operate mode the RM-14SA measures and displays readings of gross counts that are uncorrected for background. This is because the background value stored internally is initially zero and the application of background subtraction has no effect on the displayed values. If background subtraction is desired, a background value must be obtained by placing the external background switch in the *Update Background* position. When the switch is returned to the *Subtract Background* position the RM-14SA will apply the last recorded reading as the background subtraction value. The switch indicator should light indicating that background is being subtracted from the gross count rate. The unit will now display net counts on the meter, indicated by the slowly blinking *Reset* LED on the front panel.

Because the external switch is equivalent in function to the internal *Bkg Sub* switch the operation and theory covered in sections II and III will apply to the external switch as well. It is important to remember that during background updates the Response Time becomes 10 times the normal operate mode Response Time. Sufficient time must be allowed for the unit to fully respond to background levels. During background updates the meter will indicate zero counts (net count rate). To observe the gross count rate while updating background, press the *Reset* switch which will light the green LED and display the gross counts on the meter. Press the *Reset* switch again to return to background update display. Note also that during background updates the alarm checking is disabled preventing any alarms from occurring.

The external switch contains a light emitting diode (LED). Should the LED fail to light the switch should be replaced. The Eberline part number is SWPB8(2).

- Order RM14SA OPT5 (9).

11. Wall Mount Bracket

This option provides a bracket for wall-mounting the RM-14SA.

- Order RM14S OPT6 (1).

12. Counts Per Second Option

The option provides an RM-14SA with a counts per second meter and a front panel overlay indicating the different range switch multiplier positions to accomodate the CPS meter face.

The counts per second instrument may be designated as an RM-14SI to distinguish it from the counts per minute, RM-14SA. All of the previously mentioned options apply to both the counts per minute and counts per second versions as does this manual.

- Order RM14SI (5).

NO.	MODEL NO.	TYPE	TYPICAL DETECTION	NOMINAL HIGH VOLTS	USEFUL RANGE	BASIC SENSIVITY CPM PER RATE UNIT	INPUT SENSIVITITY IN mV (Cal. field)	DEAD TIME SETTING μs (Cal field)
1	AC-3-7	Scintillator	Alpha Contamination	1200 V (see note 1)	To 4.2M cpm	1 cpm per cpm	10 (10,000 cpm)	6 ($4x10^6$ cpm)
	HP-100A	Gas Proportional	Alpha and Beta-Gamma	2000 V (see note 1)	To 4.3M cpm	1 cpm per cpm	2 (10,000 cpm)	7 ($4x10^6$ cpm)
2	HP-190A	GM	Beta Contamination	900 V	To 2.7M cpm To 1000 mR/h	1 cpm per cpm 2500 cpm/mR/h	10 (2 mR/h)	255 (800 mR/h)
3	HP-210L, HP-210T, HP-260	GM	Beta Gamma Contamination	900 V	To 5M cpm To 1500 mR/h	1 cpm per cpm 3600 cpm/mR/h	10 (2 mR/h)	55 (1200 mR/h)
4	HP-270	GM	Gamma Exposure	900 V	To 4.6M cpm To 3400 mR/h	1 cpm per cpm 1350 cpm/mR/h	10 (5 mR/h)	100 (2500 mR/h)
5	HP-290	GM	Gamma Exposure	550 V	To 4.9M cpm To 52 R/h	1 cpm per cpm 93 cpm/mR/h	10 (500 mR/h)	12 (40 R/h)
6	LEG-1	Scintillator	Low-Energy Gamma or X-ray	1200 V (see note 1)	To 4.5M cpm	1 cpm per cpm	10 (4000 cpm)	8 ($4x10^6$ cpm)
7	NRD	Proportional Chamber	Neutron Dose Equivalent	2300 V (see note 1)	To 4.7M cpm To 100 rem/h	1 cpm per cpm 45 cpm/mrem//h	2 (500 mrem/h)	10 (75 rem/h)
8	SPA-3	Scintillator 2 x 2	High Sensitivity Gamma	1000 V (see note 1)	To 5M cpm To 3.4 mR/h	1 cpm per cpm 1.5M cpm/mR/h	10 (4000 cpm)	12 ($4x10^6$ cpm)
9	SPA-6	Scintillator 50mm Dia. x 60mm	Medium Sensivity Gamma	1000 V (see note 1)	To 4.9M cpm	1 cpm per cpm	10 (< 1 mR/h)	16 (3 mR/h)
10	SPA-8	Scintillator 1 x 1 Crystal	Medium Sensitivity Gamma	1000 V (see note 1)	To 4.9M cpm	1 cpm per cpm	10 (4000 cpm)	12 ($4x10^6$ cpm)

NOTE 1. Detector voltage should be set as described in the "Maintenance" section of the RM-14SA manual.

Table 7-1, Detector Information